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BULLETIN No. 74-4

Water Well Standards

CENTRAL, HOLLYWOOD,
SANTA MONICA BASINS
LOS ANGELES COUNTY

OCTOBER 1965

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources

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DEPARTMENT OF WATER RESOURCES

P. BOX 388
SACRAMENTO

August 10, 1965

Honorable Edmund G. Brown, Governor, and
Members of the Legislature of the
State of California

Los Angeles Regional Water Pollution Control Board

Gentlemen:

Bulletin No. 74-4, "Water Well Standards, Central, Hollywood, and Santa Monica Basins, Los Angeles County", reports upon a study of impairment of ground water quality by water wells conducted under authority of Section 231 of the California Water Code.

The bulletin is one of a series of reports that present minimum recommended water well construction and sealing standards for particular localities in the State where the quality of the ground water could be or has been damaged by improperly constructed or improperly destroyed water wells. In the Central, Hollywood, and Santa Monica Basins, some impairment of ground water quality has already occurred in this manner.

The report concludes that water well construction and sealing standards must be employed. The standards presented are based upon the conditions present in the Central, Hollywood, and Santa Monica Basins, Los Angeles County, and supplement the minimum standards presented in the preliminary edition of Bulletin No. 74, "Recommended Minimum Well Construction and Sealing Standards for the Protection of Ground Water Quality, State of California", July 1962.

The report recommends that the Los Angeles Regional Water Pollution Control Board, local agencies, water producers, and water well drillers adopt these standards, and apply them in a manner that will assist in preserving and improving the quality of one of Los Angeles County's most valuable natural resources, its ground water supply.

Sincerely yours,

A handwritten signature in dark ink, appearing to read "William E. Warne", written in a cursive style.

Director

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

EDMUND G. BROWN, Governor
HUGO FISHER, Administrator, The Resources Agency
WILLIAM E. WARNE, Director, Department of Water Resources
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CALIFORNIA WATER COMMISSION

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-----0-----

WILLIAM M. CARAH
Executive Secretary

ORVILLE ABBOTT
Engineer

AUTHORIZATION

This report is the result of legislation enacted to protect the ground water quality from impairment by improperly constructed, sealed, or destroyed wells. This legislation has been codified in Section 231, Chapter 2, Division 1 of the California Water Code, as follows:

"231. The department, either independently or in cooperation with any person or any county, state, federal or other agency, shall investigate and survey conditions of damage to quality of underground waters, which conditions are or may be caused by improperly constructed, abandoned or defective wells through interconnection of strata or the introduction of surface waters into underground waters. The department shall report to the appropriate regional water pollution control board its recommendations for minimum standards of well construction in any particular locality in which it deems regulation necessary to protection of quality of underground water, and shall report to the legislature from time to time, its recommendations for proper sealing of abandoned wells."

ACKNOWLEDGMENTS

Valuable data and other assistance were contributed by agencies of the Federal Government and of the State of California, by cities, counties, public districts, and private companies and individuals. This cooperation is gratefully acknowledged.

Special mention is made of the help given by the Los Angeles County Flood Control District, Roscoe Moss Company, and Water Well Supply Company.

CHAPTER I. INTRODUCTION

Ground water has been an important factor in the transformation of coastal Los Angeles County from primarily an agricultural region in the early 1900's to one of the metropolitan giants of the United States. This underground resource presently constitutes about one-half of the total water supply put to beneficial use in the area. Although the amount of water imported is increasing, the ground water basins will continue to be a major source of water supply. These basins not only act as depositories of water originating locally, but also provide regulatory storage for imported supplies. Preserving the usefulness of these natural storage reservoirs and maintaining the quality of water stored in them are vitally important to the economic growth of the Los Angeles metropolitan area.

Unfortunately, many of those utilizing this valuable resource contribute to its impairment. Improper construction or inadequate sealing of new water wells, or inadequate destruction of old wells may allow poor quality water to commingle with good quality water. Sewage and industrial wastes have, in some cases, migrated downward through inadequately sealed wells into the water-bearing materials of the basins. Good quality water along the coastal margins of the basins has been degraded by the intrusion of sea water. This occurs when ground water levels drop below sea level as a result of overpumping in aquifers that are in contact with the sea. In some areas, the sea water migrates first into the shallow aquifers, thence into deeper aquifers by way of improperly constructed or inadequately sealed wells.

An essential factor, therefore, in the prevention of further impairment of the quality of ground water in the coastal portion of

Los Angeles County is the development and application of adequate standards for well construction and sealing.

Objective and Scope of Investigation

The objective of the investigation described in this report was to formulate water well construction and sealing standards for the Central, Hollywood, and Santa Monica Basins in Los Angeles County. The use of these standards in the construction or destruction of water wells will serve to protect the quality of ground water in these basins.

To accomplish this objective, all available data concerning the hydrology, geology, and water quality of the study area were compiled from the files of the Department of Water Resources, records of other agencies and individuals, and numerous published reports. These data were used to evaluate surface and subsurface geologic and hydrologic conditions; to determine ground water quality; to locate barriers to ground water movement; to determine water elevations and direction of ground water movement; and to ascertain sources of ground water replenishment.

Most of the geologic and hydrologic information concerning the ground water basins was obtained from previous investigations and reports, particularly Appendixes A and B of Department of Water Resources' Bulletin No. 104, "Planned Utilization of the Ground Water Basins of the Coastal Plain of Los Angeles County", June 1961 and April 1962. However, a review of previous delineations and more detailed studies of the occurrence of aquifers in some areas were conducted to determine the necessity and feasibility of recommended water well sealing zones. Local water well drillers were contacted to obtain their comments and review of the proposed water well standards.

The recommended construction and sealing standards presented in this report are specific for water wells in the Central, Hollywood, and Santa Monica Basins in Los Angeles County, and supplement the minimum standards presented in the Department of Water Resources' Bulletin No. 74, "Recommended Minimum Well Construction and Sealing Standards for Protection of Ground Water Quality, State of California", Preliminary Edition, July 1962. These reports, used in conjunction with Department of Water Resources' Bulletin No. 107, "Recommended Well Construction and Sealing Standards for Protection of Ground Water Quality in West Coast Basin, Los Angeles County", August 1962, provide a basis for the development of water well construction and sealing standards throughout the Coastal Plain of Los Angeles County.

Supporting data used in this study are maintained in the files of this Department. A list of some of the pertinent references utilized in the course of the investigation is presented in Appendix A.

Area of Investigation

The area of investigation includes that portion of the Coastal Plain of Los Angeles County which is underlain by the Central, Hollywood, and Santa Monica Ground Water Basins, as shown on Plate 1, "Ground Water Basins in Coastal Plain of Los Angeles County". This area encompasses about 300 square miles and extends approximately 30 miles from the Santa Mountains southeast to the Los Angeles-Orange county line. The area is bounded by the Pacific Ocean on the northwest, in the vicinity of the City of Santa Monica.

Physiographic Features

The area of investigation consists of broad alluvial plains which range in elevation from sea level at the coastline to about 500 feet adjacent to the Santa Monica Mountains on the north. The plains are flanked by highlands on the north, northeast, and southwest. The areal extent of these physiographic features is shown on Figure 1, "Physiographic Features -- Coastal Plain of Los Angeles County".

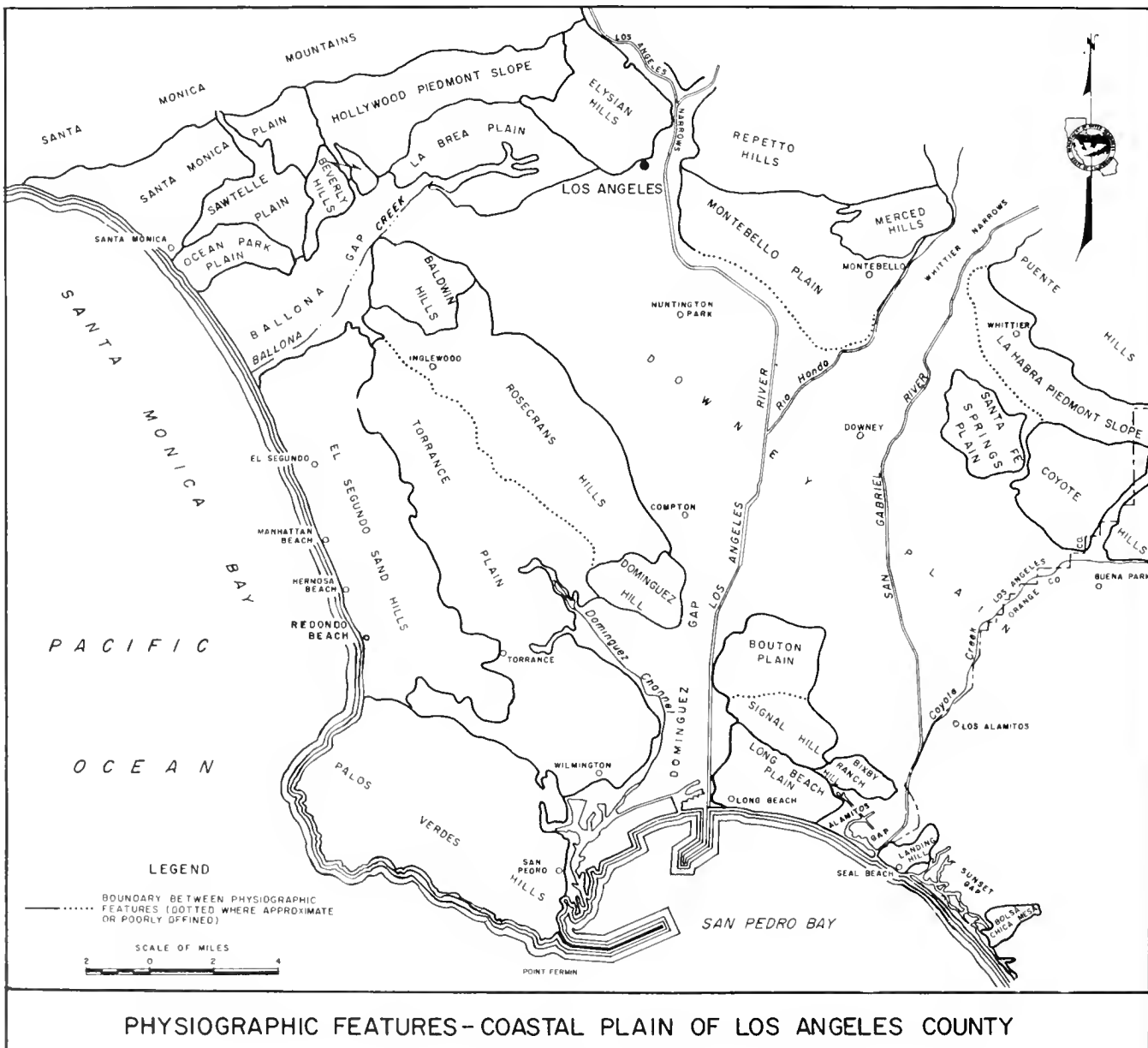


Figure 1

The Downey Plain, the largest plain, and the Sawtelle Plain, Hollywood Piedmont Slope, and La Habra Piedmont Slope include those areas where alluvium has been deposited in Recent time. Older plains of Pleistocene age are Santa Monica Plain, La Brea Plain, Montebello Plain, Santa Fe Springs Plain, and Ocean Park Plain.

Highlands adjacent to these alluvial plains are the Santa Monica Mountains to the north, a rugged, east-west trending range with a maximum elevation of 2,126 feet. Other highlands, lower in elevation, adjoin the plains to the northeast. They are the Elysian, Repetto, Merced, Puente, and Coyote Hills. The Elysian and Repetto Hills are separated by the Los Angeles Narrows. The Whittier Narrows is an erosional gap between the Merced and Puente Hills.

A series of low hills border the study area to the southwest. From the southeast to the northwest they are Bixby Ranch Hill, Signal Hill, Dominguez Hill, Rosecrans Hills, and Baldwin Hills. These hills are the surface expression of the Newport-Inglewood uplift. The Beverly Hills are a northwest extension of this belt of hills. Erosional gaps in the Newport-Inglewood uplift are: Ballona Gap, Dominguez Gap, and Alamitos Gap. The portion of the study area west of the Newport-Inglewood uplift is bordered on the south by the El Segundo Sand Hills.

Three main rivers, the Los Angeles River, San Gabriel River, and Rio Hondo, flow into the area of investigation from the interior valleys. The Los Angeles River drains the San Fernando Valley, flowing through the Los Angeles Narrows, then southward across the coastal plain, and out of the study area through Dominguez Gap. The San Gabriel River and Rio Hondo flow from the San Gabriel Valley through Whittier Narrows

into the coastal plain. The Rio Hondo flows southwesterly from Whittier Narrows across the coastal plain approximately 9 miles before joining the Los Angeles River. The San Gabriel River flows southerly across the coastal plain and discharges into the Pacific Ocean through Alamitos Gap. Ballona Creek drains the northwest portion of the coastal plain, flowing southwesterly through Ballona Gap to discharge into the Pacific Ocean.

Climate

The average seasonal precipitation in the study area from October 1934 through September 1957 ranged from 12 inches in Alamitos Gap to more than 23 inches in the Santa Monica Mountains. The region is semi-arid, although the prevailing south and southwest winds moving in from the Pacific Ocean tend to moderate both the summer and winter conditions, serving to make the climate uniformly mild. According to records at Los Angeles from 1915 to 1963, the mean annual temperature is 63.3° F. The range of temperature during the year is not extreme; killing frosts occur infrequently. The coldest month is January, for which the mean minimum temperature is 46.4° F. The warmest month is August, for which the mean maximum temperature is 82.3° F.

Cultural Development

The area of investigation has undergone a significant shift from a primarily agricultural region to a highly urbanized complex of large residential tracts and industrial developments within a relatively short span of time. As recently as 25 years ago, development in the area consisted of small suburban communities surrounded by truck farms, orchards, large ranges and grazing lands. The change in land use is indicated by

the decrease in irrigated agricultural acreage from about 58,500 acres in 1932 to about 18,000 acres in 1960, while during the same period, the amount of land for urban-suburban use increased from about 123,000 acres to about 218,000 acres.

Changes in population have been equally as significant as the changes in land use. In 1930, the population of the study area was approximately 1,040,000. In 1940, this figure had increased to 1,780,000 and by 1960, under the influence of a post-war boom, the total population increased to almost 3,000,000.

Water Use

The overall increase in land use, together with the large increase in population, has resulted in corresponding increases in demands for water in the area. Figure 2, "Water Use in Central, Hollywood, and Santa Monica Basins", depicts the increase in local ground water extractions, as well as water imported for agriculture and urban-suburban use from 1934-35 to 1960-61. Local ground water extractions amounted to about 169,000 acre-feet in 1934-35. By 1960-61, this figure increased more than 100 percent to about 358,000 acre-feet.

The amount of imported water supplied to the area of investigation has increased correspondingly to keep pace with the growing demands as shown on Figure 2. The major sources of imported water are Colorado River water delivered through the facilities of The Metropolitan Water District of Southern California and its member agencies, and water imported from Owens and Mono Valleys through the facilities of the City of Los Angeles Department of Water and Power.

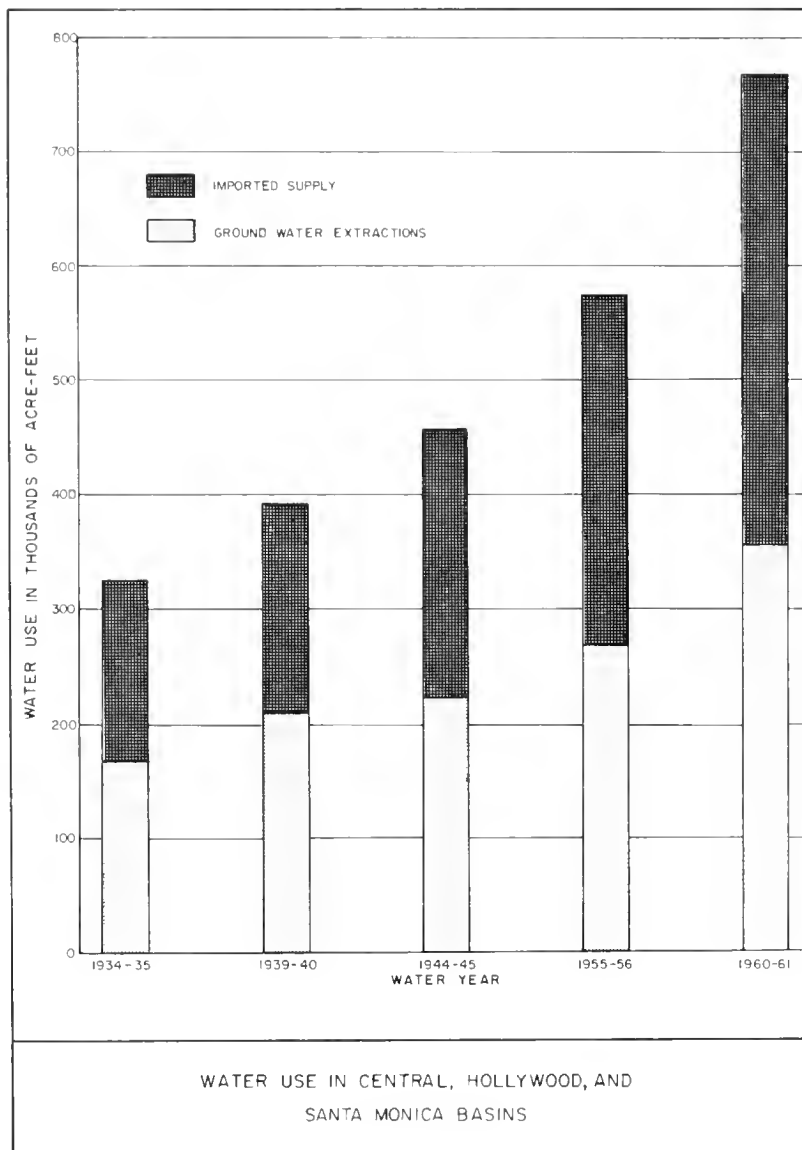


Figure 2

As shown on Figure 2, despite an increase of imported water, ground water continues to provide almost one-half of the water put to beneficial use in the area of investigation. The heavy extractions of ground water to meet the increased demands have resulted in overdraft in the Central and Santa Monica Basins. The consequent lowering of water

levels in these basins has permitted sea water to move inland and impair large quantities of ground water. The effects of uncontrolled waste discharges have further depleted the amount of available fresh water in the area of investigation.

Other factors contributing to the depletion of available fresh water supplies in the area are inadequately constructed or improperly destroyed water wells. Although intended only to extract water for beneficial uses, these wells can contribute to the impairment of the ground water quality by serving as conduits to introduce impaired water into the several aquifers underlying the study area that contain good quality water.

CHAPTER II. OCCURRENCE AND MOVEMENT OF GROUND WATER

The Central, Hollywood, and Santa Monica Basins consist mainly of unconsolidated sediments (considered water-bearing materials) underlain by and bounded on the north and east by consolidated sediments and crystalline rocks (considered nonwater-bearing). Ground water is stored within the interstices of the unconsolidated sediments and in the cracks and fractures of the consolidated sediments and crystalline rocks.

The nature and extent of the ground water basins and the distribution and sequence of the water-bearing materials contained therein are determined through geologic studies of the area. Hydrologic studies determine the replenishment of ground water supplies and the manner and amount of discharge of ground water.

This chapter discusses the geologic and hydrologic aspects affecting the occurrence and movement of ground water in the study area, emphasizing those factors that directly influence water well construction and sealing. The information presented is based primarily on data in Appendixes A and B of Department of Water Resources' Bulletin 104, which provide more detailed information on the geology and hydrology of the area.

Geologic History

As stated previously, the Central, Hollywood, and Santa Monica Basins are a part of and underlie the Coastal Plain of Los Angeles County. The land forms that make up the coastal plain are the result of an exceedingly complex geologic history. They are the product of periods of deformation, deposition of sediments, sea level changes, and erosional patterns. Deposition of the water-bearing sediments, as well as the development of

the ground water basins which contain them, is the result, for the most part, of geologic events since Pliocene time.

During the Pliocene and Pleistocene epochs the coastal plain was essentially a downwarped block which received detritus from the adjacent highlands. These materials were deposited in an environment that fluctuated between marine, lagoonal, and continental conditions. Contemporaneously, folding and faulting of the deposited materials were occurring as tectonic activity continued throughout Pleistocene time. Generally, during Pliocene and early Pleistocene time the environment of deposition was predominantly marine. As time progressed, the basins were filled, and by Recent time the alluviated plain present today was developed. The surface distribution of the geologic units that make up the area of investigation is shown on Plate 2, "Areal Geology and Well Location Map".

Sequence and Water-Bearing Characteristics of Geologic Units

Water-bearing materials in the study area consist of layers of gravel and sand, usually separated by layers of silt and clay. The gravel and sand layers have relatively large spaces between the particles where water can be stored and through which water can be transmitted. These coarser-grained deposits, which yield water to wells in usable amounts, are called aquifers. In contrast, the finer-grained materials, particularly the clays, have only minute spaces between the particles and therefore offer greater resistance to the movement of water. The layers between aquifers which do not furnish enough water to supply water wells are called aquicludes. Generally, aquicludes reduce the rate of vertical movement of ground water, including movement downward from the ground surface and movement between aquifers.

There have been 12 aquifers identified within the study area.

The occurrence of these aquifers is shown on Plates 3A and 3B, entitled "Idealized Geologic Sections". Relationships between aquifers are shown on Figure 3, entitled "Generalized Stratigraphic Column, Coastal Plain of Los Angeles County".

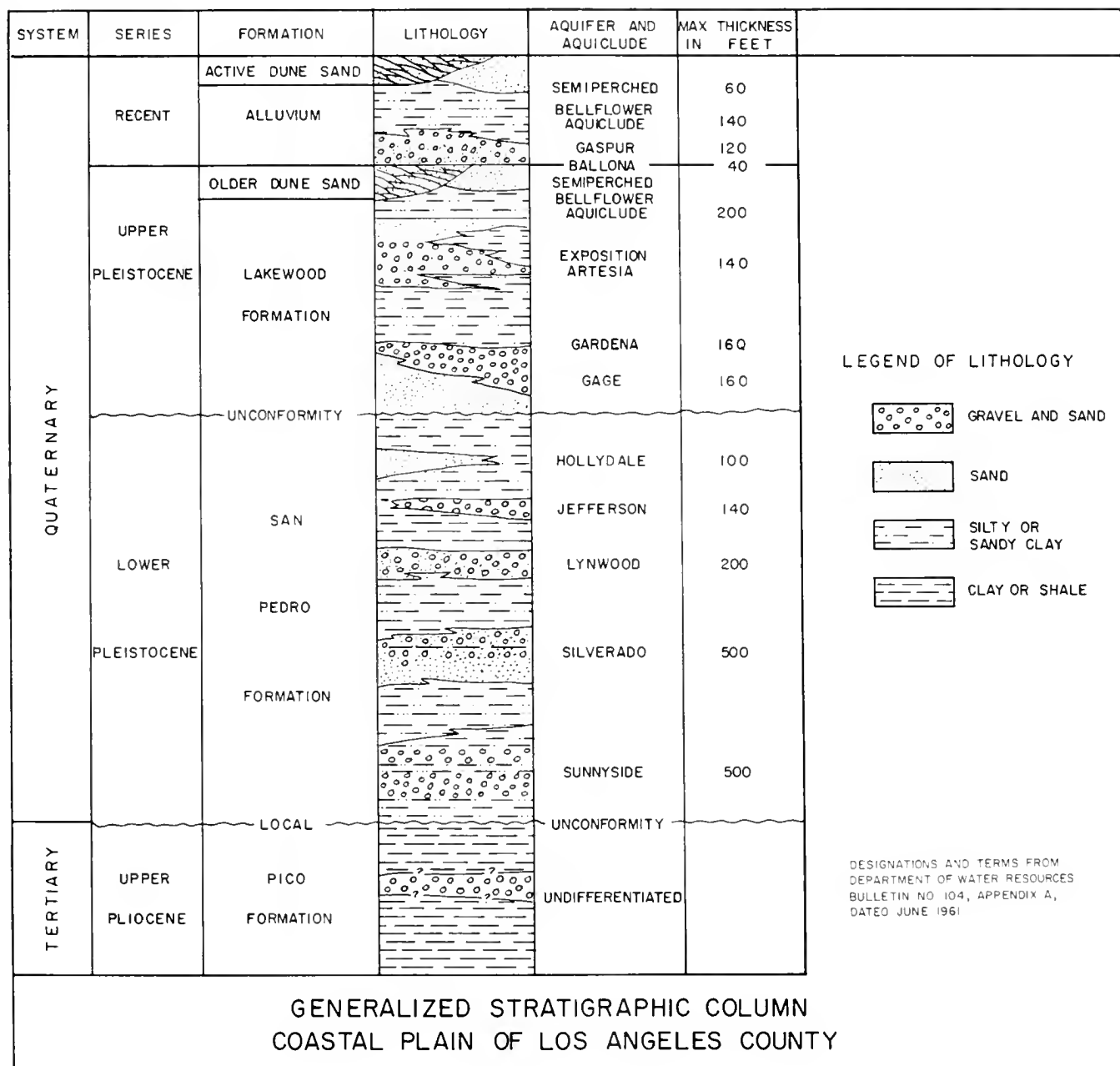


Figure 3

Although each aquiclude is important in retarding movement of ground water between the aquifers it separates, only the uppermost aquiclude has been named. Because of its importance in retarding the downward percolation of surface waters, the Bellflower aquiclude is delineated. Its relationship to the aquifers is illustrated in Figure 2.

Descriptions of the geologic formations shown on Plate 2 are presented from youngest to oldest in the following paragraphs with discussions of the respective aquifers as well as the Bellflower aquiclude. The geologic formations discussed include: alluvium and active dune sand, all of Recent age; older dune sand and Lakewood Formation, all of late Pleistocene age; San Pedro Formation of early Pleistocene age; Pico Formation of Pliocene age; Repetto Formation of Pliocene age; and nonwater-bearing formations of pre-Pliocene age.

Alluvium

Recent alluvium is primarily stream-deposited gravel, sand, silt, and clay. Identified geologic members within the alluvial deposits include the Semiperched, Gaspur, and Ballona aquifers, and the Bellflower aquiclude. Portions of the latter, and of the Semiperched aquifer, are of late Pleistocene age. For convenience, they are described here, together with the portions of Recent age.

Semiperched Aquifer. Areal distribution of the deposits which make up the Semiperched aquifer is very discontinuous, although some attain a maximum thickness of 60 feet. Consisting of lenses of coarse sands and gravels, the deposits are found on or near the surface of much of the coastal plain. Where the underlying aquifers are confined, the Semiperched aquifer is separated from them by materials of relatively low permeability.

Gaspur Aquifer. The Gaspur aquifer is located over a broad path extending generally from north to south through the middle of the Central Basin, as shown on Plate 4 entitled, "Areal Extent of Aquifers in Central and Hollywood Basins Related to Supplementary Sealing Standards". The main portion of the aquifer extends in a broad band from Whittier Narrows southwesterly to Dominguez Gap. A western arm of the aquifer extends northward to Los Angeles Narrows. Layers of coarse sands and gravels make up a large portion of the aquifer which apparently represents ancestral channels of the Los Angeles and San Gabriel Rivers. The coarse texture of the aquifer lends itself to excellent water production.

Ballona Aquifer. The Ballona aquifer is present throughout the south half of the Santa Monica Basin, from the ocean to a point just east of the Overland Avenue fault.

The materials making up the aquifer are a result of deposition by a former tributary of the Los Angeles River and by the present Ballona Creek. The aquifer consists of coarse sand and gravel and ranges in thickness from less than 10 feet to a maximum of 40 feet.

Bellflower Aquiclude. The Bellflower aquiclude is widely distributed through the Central and Santa Monica Basins, but is absent in the Hollywood Basin. The thickness of the aquiclude varies considerably, the maximum thickness being 140 feet. In the Central Basin, the aquiclude is nearly continuous in the pressure area but is essentially absent in the Whittier and Los Angeles Forebays and in a narrow strip along the base of the Santa Monica Mountains, as shown on Plate 5, "Lines of Equal Elevation on the Base of the Bellflower Aquiclude". The Bellflower aquiclude is

present in the Santa Monica Basin except in the area adjacent to Baldwin Hills and in a strip about 3 miles wide extending along the south flank of the Santa Monica Mountains.

The Bellflower aquiclude is a heterogeneous mixture of continental, marine, and wind-blown sediments, predominantly consisting of clays and silts. Lenses and pockets of sandy or gravelly clays occur within the aquiclude.

Active Dune Sand

Dune sand deposits shown on Plate 2 occur along the coast from Ballona Creek southward. The deposits are lens-shaped and contain well-sorted, fine- to medium-grained sand. The deposits are primarily outside the study area; only the north edge of the deposits are within the Santa Monica Basin. They do not affect ground water conditions within the area of investigation.

Older Dune Sand

Older dune sand present in the Santa Monica Basin was deposited in late Pleistocene time and is composed primarily of fine- to medium-grained sand containing minor sandy silt, clay, and gravel lenses. The deposits are relatively unimportant to ground water occurrence.

Lakewood Formation

The Lakewood Formation of late Pleistocene age underlies most of the area of investigation. The basal portion consists of fairly continuous coarse-grained units of sand and gravel containing some lenses of clay and sandy silt. The upper portions of the Lakewood Formation are made up of discontinuous permeable zones with considerable variation in

grain size. Typical of alluvial and floodplain deposits, fine-grained sediments make up from 40 to 80 percent of the total deposits.

Among the aquifers present in the Lakewood Formation are the Artesia-Exposition aquifers and the Gage-Gardena aquifers. In some areas, the Lakewood Formation includes portions of the Semiperched aquifer and the Bellflower aquiclude which are described under Recent alluvium.

Artesia-Exposition Aquifers. The Artesia-Exposition aquifers, although located in separate geographical areas, are stratigraphically equivalent and similar in composition. The Artesia aquifer is present in the Central Basin, east of the Gaspur aquifer. The presence of poor quality water in the Artesia aquifer near Norwalk, which will be discussed in Chapter III, requires supplementary water well standards to prevent the extension of this poor quality water to other aquifers. The areal extent of the Artesia aquifer is shown on Plate 4. The Exposition aquifer extends from the Gaspur aquifer westerly to the Newport-Inglewood uplift and northerly into the Hollywood Basin.

Both aquifers are composed largely of coarse to fine sand, some gravel, and interbedded silts and clays. Generally, the grain size of the materials decreases in a southwesterly direction.

The Artesia-Exposition aquifers merge beneath the Gaspur aquifer, as shown on Sections A-A'-A" and B-B' of Plate 3A, and Sections E-E' and F-F'-F" of Plate 3B, and are in limited hydraulic continuity with the overlying Gaspur aquifer. However, the coarse-grained, highly permeable character of the Gaspur aquifer is in marked contrast to those of the Artesia-Exposition aquifers. Particularly in that area south of Imperial Highway, materials composing the Artesia-Exposition aquifers located beneath the

Gaspur aquifer are predominantly fine-grained, containing primarily fine sands, silts, and clays with few gravels. As a result, in this area the movement of ground water from the Gaspur aquifer to the underlying Artesia-Exposition aquifers is small.

Gage-Gardena Aquifers. The Gage and Gardena aquifers are the basal members of the Lakewood Formation and were deposited contemporaneously. The Gardena aquifer is the coarse-grained phase of the unit, whereas the Gage includes the remaining aquifer materials which are predominantly fine-grained sands and silty sands.

The Gage aquifer is widespread, extending throughout most of the study area. It is lacking in the Santa Monica Basin and in the Whittier Area. The Gage aquifer attains a maximum thickness of 120 feet in Central Basin, but generally ranges in thickness from 40 to 80 feet.

The Gardena aquifer is an important source of water to numerous wells. It occurs within Central Basin as three generally isolated units. The largest extends southwesterly from Whittier Narrows. The second unit extends from the vicinity of Lynwood southwesterly out of the basin over the Newport-Inglewood uplift. The third unit is present at the mouth of the Los Angeles Narrows.

San Pedro Formation

The San Pedro Formation underlies all the basins in the study area and is positioned between the Lakewood Formation and the underlying Pico Formation. Sedimentary types forming the San Pedro Formation have a wide variation in grain size and are unevenly distributed. Both fine-grained marine sediments and river-deposited sands and gravels occur in

the formation. The lower San Pedro Formation is not only coarser grained, generally, than the upper San Pedro, but the sand and gravel layers are more continuous and more widespread. Aquifers contained in the lower San Pedro Formation include two important water-producing zones -- the Silverado aquifer and the overlying Lynwood aquifer. Other aquifers of the San Pedro Formation that have been identified in the study area include the Sunnyside aquifer (underlying the Silverado aquifer) and relatively minor aquifers overlying the Lynwood aquifer, which are the Hollydale and Jefferson aquifers.

Hollydale and Jefferson Aquifers. The areal extent of the Hollydale and Jefferson aquifers is limited to the Central Basin. They are characterized by patchiness, and are variable both in grain size and thickness. They are not important water-producing zones in the study area.

Lynwood Aquifer. The Lynwood aquifer is continuous within the Central Basin and has been identified in wells in the Hollywood Basin. It is absent in the Santa Monica Basin. The areal extent of the Lynwood aquifer is shown on Plate 4. The Lynwood aquifer is important in relation to supplementary water well standards for the prevention of saline water impairment, which will be discussed in Chapters III and IV.

Sediments of the Lynwood aquifer are essentially marine deposits consisting of sand and gravel alternating with silts and clays, all of which are locally cemented. The Lynwood aquifer ranges from about 50 feet to about 200 feet in thickness.

Silverado Aquifer. The Silverado aquifer, widespread in distribution, is probably the most important aquifer in the area of investigation.

Present throughout Central Basin, it also occurs in the Santa Monica and Hollywood Basins and extends southeastward beyond the limits of the study area into Orange County. The aquifer was first identified in the West Coast Basin, southwest of the study area.

The Silverado aquifer includes continental and marine-deposited sands and gravels with interbedded lenses of silt and clay. Thickness of the aquifer varies from less than 50 feet to a maximum of 500 feet. Folding and faulting have deformed the Silverado aquifer considerably.

Sunnyside Aquifer. The Sunnyside aquifer underlies a wide area within Central Basin. Thin deposits probably occur in the Hollywood Basin but the aquifer is not known in the Santa Monica Basin. Thickness of the Sunnyside aquifer within Central Basin ranges from less than 50 feet to more than 300 feet. In the central portion of the Central Basin, few water wells penetrate the Sunnyside aquifer.

Pico Formation

Underlying the San Pedro Formation is the Pico Formation, which is Pliocene in age. It is divided into three members, of which the upper member is a potential source of water. The upper member consists of sand, silt, and clay, interbedded with some gravels. The middle and lower members of the Pico Formation are generally composed of micaceous siltstone and interbedded sandstone and claystone.

Repetto Formation

Rocks of early Pliocene age exposed in the study area are part of the Repetto Formation. These deposits underlie most of the study area and are composed mostly of siltstone with layers of sandstone and

conglomerate. Although these materials probably contain water in the interstices, it is believed they transmit water only slowly, and water yields would be limited.

Nonwater-Bearing Formations

In addition to the previously mentioned geologic formations of Recent, Pleistocene, or Pliocene age, numerous older formations, which are considered nonwater-bearing, appear on Plate 2. Although these older formations do not contain water that is readily available, they are important to the study area because they make up the surrounding mountain highlands and also form the impermeable basement complex beneath the ground water basins. Generally from youngest to oldest, these formations are the Modelo, Puente and Topanga of Miocene age; the Martinez of Paleocene age; and the Chico of Cretaceous age. In addition to the sedimentary rocks, the nonwater-bearing units include Miocene volcanics and pre-Tertiary igneous intrusives and the Santa Monica slate.

Structure

Geologic structures in the study area that affect the occurrence and movement of ground water include both faults and folds. Faults have disrupted water-bearing strata enough to interrupt the flow of ground water, and the folding of sedimentary formations has exposed nonwater-bearing rocks that generally limit the movement of ground water and has resulted in the dewatering of potentially water-bearing materials. These structural effects on the aquifers of the study area are illustrated by the sections shown on Plates 3A and 3B.

Generally aligned along regional uplifts and depressions, the structures may be grouped into mountain and foothill structures, transitional structures, the South Gate-Santa Ana depression, the Newport-Inglewood uplift, and the structure west of the Newport-Inglewood uplift. The locations and extent of the geologic structures are shown on Plate 2.

Mountain and Foothill Structures

The study area is bordered to the north and northeast by mountains and hills which have been uplifted by folding and faulting. They include the Santa Monica Mountains and the Elysian, Repetto, Merced, and Puente Hills. These highlands are almost entirely composed of nonwater-bearing materials and are boundaries of the basins within the study area.

Transitional Structures

The hills on the northeast margin of the coastal plain are flanked by the transitional structures which consist of partially buried anticlines and synclines. Structural units include: the Hollywood syncline; La Brea structural high; Boyle Heights anticline; Santa Fe Springs-Coyote Hills uplift, which is made up of the Santa Fe Springs, Leffingwell, and West Coyote anticlines; and La Habra syncline. Ground water movement is restricted by the anticlinal structures, due to the thinning of water-bearing units, and the uplift of nonwater-bearing materials.

South Gate-Santa Ana Depression

The South Gate-Santa Ana depression is a generally downwarped area and underlies the Downey Plain in the Central Basin. This depression is, in general, parallel to the Newport-Inglewood uplift and extends from the vicinity of Beverly Hills southeasterly into Orange County. From the

transitional structures to the north and northeast, the water-bearing formations generally dip southwesterly toward the Paramount syncline, the principal structure of the depression, then turn up again onto the Newport-Inglewood uplift. The Los Alamitos fault is southeast and parallel to the Paramount syncline axis. The depression also contains the Norwalk syncline. Ground water movement in the South Gate-Santa Ana depression is generally in a southerly direction, but varies near the Newport-Inglewood uplift, as well as around localized pumping depressions.

Newport-Inglewood Uplift

The Newport-Inglewood uplift extends southeasterly from Beverly Hills to the Los Angeles-Orange county line and is the boundary between Hollywood and Central Basins to the northeast and Santa Monica and West Coast Basins on the southwest. The uplift is a series of en echelon faults and low anticlinal folds which underlie the series of hills discussed in Chapter I.

Faults of the uplift act as barriers to the movement of ground water, particularly in the deeper, older formations. Displacement is less in the younger formations, and in deposits at the surface, faulting is minor and folding is predominant. Structures of the Newport-Inglewood uplift that are apparent at the surface include, from northwest to southeast, Inglewood fault; Baldwin Hills uplift; Potrero fault and dome; Rosecrans anticline; Avalon-Compton fault; Dominguez and Long Beach anticlines; Cherry Hill, Northeast Flank, Pickler, and Reservoir Hill faults; and Seal Beach structure.

Structure West of the Newport-Inglewood Uplift

Underlying the Santa Monica and Sawtelle Plains is the northwestern terminus of a structurally downfolded area. Features of this area include the Overland Avenue and Charnock faults and unnamed fold structures trending east-west and dipping gently to the south beneath Ballona Gap.

The Overland Avenue and Charnock faults are essentially parallel, trending northwest across Ballona Gap. They are barriers to ground water movement; ground water levels east of the Overland Avenue fault are 60 to 100 feet higher than those west of the fault. Displacement of the Silverado aquifer on the Charnock fault, as shown on Section A-A'-A" of Plate 3A, has disrupted the hydraulic continuity, restricting ground water movement.

Ground Water Basins

The study area includes three of the four ground water basins (technically, ground water subbasins) that are part of the coastal plain. The three include: Central, Hollywood, and Santa Monica Basins. The fourth basin, outside the study area, is the West Coast Basin. The locations of these basins and their boundaries are shown on Plate 1.

Each basin contains one or more permeable formations capable of furnishing a substantial water supply. They are generally separated along geologic structures previously discussed, some of which act as barriers and affect ground water movement. A simplified line representing the Newport-Inglewood uplift separates the coastal plain into Santa Monica Basin and West Coast Basin to the west, and Hollywood Basin and Central Basin to the east of the uplift.

The Ballona escarpment, the steep erosional scarp on the south side of Ballona Gap that extends from Baldwin Hills to the ocean, is the boundary separating the Santa Monica Basin from the West Coast Basin. The escarpment is not a physical restriction to the movement of ground water between basins but it does generally overlies a ground water divide developed as a result of ground water extractions.

Hollywood Basin is separated from the Central Basin by the crest of the La Brea structural high, which restricts ground water in the Hollywood Basin from moving into the Central Basin, except through the shallow deposits of the Lakewood Formation. A ground water trough, or pumping depression, in the vicinity of Culver City has developed a ground water divide, and intercepts all flow from the Hollywood Basin.

The Central Basin is divided into four areas as shown on Plate 1: The Los Angeles and Montebello Forebays, the Whittier Area, and the Central Basin Pressure Area. Generally, the forebays are areas of unconfined ground water in which recharge of the basin occurs. The pressure area consists of aquifers overlain with relatively impermeable layers that restrict movement of ground water. Water in wells in the pressure area rises above the top of the aquifer because of the confined pressure conditions. Although this simplified division is essentially correct, the impermeable layers, or aquicludes, extend into the forebay areas in some places, and lenses of sand and gravel exist within the confining layers of the pressure area. The Whittier Area, located in the eastern part of the Central Basin, is underlain by poorly defined aquifers and aquicludes which contain partially confined ground water.

Replenishment and Discharge of Ground Water

The ground water basins are replenished by surface and subsurface inflow from the bordering hills and mountains and from the adjacent San Gabriel and San Fernando Valleys, by precipitation, by applied water, and by artificial recharge of either local or imported water through surface spreading operations and well injection methods.

Except for water received through subsurface inflow or by artificial recharge through injection wells, water replenishing the basin reaches the ground water body by percolation from the ground surface. The areas open to direct percolation of precipitation and applied water, however, have been greatly reduced by the extensive paving operations that have accompanied the urbanization of the basin regions. In addition, extension of sewer systems discharging through ocean outfalls, improvement in surface drains, and lining of river channels have all resulted in diminishing the amount of water percolating into ground water basins. Offsetting these conditions to some degree has been the expansion of artificial recharge programs.

Historically, ground water in the Central Basin has been replenished mainly from surface and subsurface flows into the basin through the Los Angeles and Whittier Narrows. In recent years, imported Colorado River water has also become an important source of replenishment.

Normal flow from the study area under natural conditions has been to the Pacific Ocean. However, in recent years, increased extractions of ground water, combined with a reduction in the amount of ground water replenishment, have caused the water table to be lowered. Locally the normal gradients have even been reversed. This has permitted sea

water to move inland in some coastal areas. In other areas troughs, or pumping depressions, in the ground water surface have developed.

The major discharge of ground water in the Central, Hollywood, and Santa Monica Basins today is by pumping. The water not consumptively used is eventually transported to the ocean through sewers. Evapotranspiration processes account for only a minor amount of the ground water naturally discharged from the basins.

Ground Water Movement

Ground water in the Central Basin generally moves in a westerly and southwesterly direction from the forebay areas into the Central Basin Pressure Area except in localized regions where these flows are influenced by local geologic and hydrologic conditions. There is very little subsurface outflow from the Central Basin because most of the ground water in this region moves to a series of pumping troughs developed along the Newport-Inglewood uplift. From north to south the series include troughs: north of Dominguez Hill, adjacent to the Cherry Hill fault; north of Signal Hill; and in the Lakewood area. From these areas the water is extracted for industrial, irrigation, and domestic uses.

Extractions of ground water have exceeded the rate of replenishment and, as a result, water levels in the Central Basin have declined to the extent that upper water-bearing zones have been partially dewatered, and in the Alamitos Gap sea water has moved inland to intrude and impair some of the fresh water aquifers. Although the Los Angeles County Flood Control District has been artificially recharging the Central Basin with imported Colorado River water in spreading grounds below the Whittier Narrows, the dewatered conditions in the shallow water-bearing zones have not been offset.

Ground water in the Hollywood Basin generally moves to the southwest. Some ground water in the Lakewood Formation probably moves south across the La Brea structural high but, generally, ground water in the Hollywood Basin moves to a pumping depression in the area southeast of Beverly Hills and adjacent to the Inglewood fault.

Discharge of ground water from the Hollywood Basin is primarily by pumping from wells for consumptive use. Exported water accounts for a minor quantity of outflow from the basin.

Ground water in the Santa Monica Basin generally moves toward the south, in the direction of Ballona Gap. However, sizable extractions of ground water in the past have been responsible for a decline in water levels in the basin permitting sea water to flow inland. Today, few wells are extracting water from the basin, and the ground water gradient is apparently returning to a general southward direction.

CHAPTER III. QUALITY OF WATER AND ITS IMPAIRMENT

The purpose in formulating water well construction and sealing standards for the Central, Hollywood, and Santa Monica Basins is to help protect and preserve the quality of ground water. To establish standards that will be effective in achieving this, a knowledge of the ground water quality of the basins and an understanding of the factors affecting that quality are essential. This chapter describes the quality of ground water, quality of imported water, and impairment of ground water quality. Water quality criteria utilized in this chapter to evaluate the surface and ground waters are presented in Appendix B.

Ground Water Quality

The quality of ground water in the aquifers of the Central, Hollywood, and Santa Monica Basins was determined on the basis of approximately 600 mineral analyses compiled from department files and the records of other water agencies. Included in these data are some relatively early analyses which provide information regarding historical ground water quality conditions in these basins. Thus, by comparing them with present water quality conditions, the occurrence and degree of impairment in these basins can be ascertained.

Generally, ground water extracted from the aquifers of the Central, Hollywood, and Santa Monica Basins prior to the 1940's was considered acceptable for most beneficial uses. The mineral character was primarily calcium bicarbonate. Mineral analyses of ground water from aquifers in these basins prior to 1940 are shown in Table 1. The water wells from which the samples listed in Table 1 and in subsequent tables

were obtained are identified by the state well numbering system which is explained in Appendix C. These locations are shown on Plate 2.

TABLE 1

ANALYSES OF GROUND WATER FROM REPRESENTATIVE WELLS
IN THE AREA OF INVESTIGATION PRIOR TO 1940*

State well number	Date sampled	In parts per million								Per- cent Na
		Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₄	TDS	
<u>Gaspur Aquifer</u>										
2S/13W-14L1	3-23-32	141	38	73	278	184	69	0.4	778	24
3S/12W-10E1	12-10-25	68	13	32	272	36	19	2.0	328	24
-19L1	9-21-39	53	11	31	235	29	13	0.0	255	28
4S/13W- 2P4	7-22-31	65	9	52	223	72	27	0.0	338	37
<u>Lakewood Formation</u>										
2S/11W-30N6	12-30-32	88	24	37	314	88	27	3	425	18
3S/12W- 9L1	12-10-25	61	10	24	236	31	9	5	275	21
-12G2	5- 1-25	73	13	39	305	59	17	0	377	27
-24G	5-29-25	66	1	49	247	53	14	2	333	33
-33R	11-24-25	53	6	21	216	13	6	1	260	22
<u>San Pedro Formation</u>										
3S/12W-29K	11-28-25	40	8	33	208	17	10	1	236	34
-36B	5-14-25	52	9	19	200	29	10	1	240	20
4S/12W- 1D1	6- 1-25	54	7	16	208	16	5	1	237	18
-21M3	10-19-21	22	3	47	164	13	12	1	209	60
-34B1	3-25-32	8	3	68	162	12	16	1	189	83

*U. S. Geological Survey, Water Supply Paper 1136, "Native and Contaminated Ground Waters in the Long Beach-Santa Ana Area, California", 1953.

After 1940, it became apparent that the mineral quality of ground water in the aquifers of Recent and upper Pleistocene age was being impaired because variations in the character and quality of the ground water began to appear. These variations are attributed to the numerous waste discharges which have come into contact with and commingled with

ground water in the aquifers. Although the pollution effects of these waste discharges have been substantially reduced through the efforts of the Los Angeles Regional Water Pollution Control Board and other agencies, impairment of ground water continues due to the migration of those wastes which were discharged prior to regulatory control.

Ground water from the lower aquifers, that is, aquifers occurring in lower Pleistocene strata, is generally of suitable quality for most beneficial uses, but has also shown signs of impairment in certain localities. This is particularly true in Santa Monica Basin where the Silverado aquifer has been intruded by sea water and the ground water quality has become unacceptable for most purposes. Sea-water intrusion has also impaired ground waters in the lower aquifers of the Central Basin in Alamitos Gap.

The water quality of each of the aquifers in the Central, Hollywood, and Santa Monica Basins is discussed in the following paragraphs.

Semiperched Aquifer

Mineral analyses of ground water from the Semiperched aquifer indicate that this water has been degraded. Where this has occurred, it is unacceptable for domestic and municipal use according to United States Public Health Service standards, and is considered class 2 or 3 for agricultural purposes. Mineral character of this water tends to vary considerably within the area of investigation. The total dissolved solids concentration of semiperched water varies from 34,145 parts per million (ppm) in coastal areas where sea-water intrusion has occurred to 392 ppm inland. Analyses of ground water from selected wells in the Semiperched aquifer are shown in Table 2.

TABLE 2
ANALYSES OF GROUND WATER FROM SELECTED WELLS
IN THE SEMIPERCHED ZONE

State well number	Date sampled	Constituents in parts per million								Per- cent Na
		Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₃	TDS	
3S/11W-21B1	5- 5-54	--	--	--	116	91	92	--	392	--
3S/13W-24R7	2-18-52	189	29	111	221	136	372	4	1,158	29
4S/13W- 2P4	1-31-57	138	34	122	351	197	183	0	976	35
5S/12W- 2G7	10- 5-60	480	1,251	10,878	310	2,490	18,900	0	34,145	--

Gaspur Aquifer

Prior to the 1940's, the native waters throughout the Gaspur aquifer were generally acceptable for most beneficial uses with the exception of portions of the westerly arm of the aquifer. Today, although the water is still generally acceptable for most beneficial uses, impairment of the waters has occurred, and, in local areas, the water is unacceptable.

Mineral analyses of water samples taken before 1940 indicate the total dissolved solids concentration throughout most of the aquifer ranged from 250 to 350 ppm, as shown in Table 1. The water in the western arm of the aquifer was apparently of poorer quality than in the rest of the aquifer as indicated by the analysis of water from the well identified by state well number 2S/13W-14L1 in Table 1. The mineral character of the ground water was primarily calcium bicarbonate.

Beginning with World War II, expansion of industry and urbanization in the coastal plain was accompanied by the problem of disposing of industrial and domestic wastes. Initially, little regulation of waste disposal was employed in the area and much of these wastes were indiscriminately discharged directly to the ground surface and permitted to percolate into the underlying aquifers.

Although most improper waste disposal methods have since been eliminated through the application of regulatory measures, the ground water in the Gaspar aquifer had already been impaired in some areas. Total dissolved solids concentration of water well samples now ranges from 251 ppm to 997 ppm, as shown in Table 3.

TABLE 3
ANALYSES OF GROUND WATER FROM SELECTED WELLS
IN THE GASPUR AQUIFER

State well number	Date sampled	Constituents in parts per million								Per- cent Na
		Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₃	TDS	
2S/12W-25A1	2-27-62	20	12	75	36	133	68	0.0	327	62
2S/13W-34D4	9-22-53	187	49	86	320	311	172	8.8	997	20
3S/12W-18D5	5-20-59	60	18	42	249	68	25	0.9	367	28
3S/12W-22C3	10-20-55	137	26	38	332	122	83	1.0	748	14
3S/12W-29J1	7- 9-59	54	11	22	242	17	10	0.2	251	19
3S/13W-25N3	5- 2-57	150	27	77	350	208	106	2.0	755	26
3S/13W-25G3	8- 7-51	149	19	114	282	119	192	3.0	923	35
4S/13W- 2J3	8- 7-57	150	21	112	366	158	170	0.0	794	35

Impairment of ground water in the Gaspar aquifer by industrial waste disposal is indicated by analyses of water samples from wells in the vicinity of Alameda Street and Firestone Boulevard, in the area east of Lakewood Boulevard along Rosecrans Avenue, and in Dominguez Gap. Sea water has intruded into the Gaspar aquifer in the West Coast Basin outside the study area, and could extend into Central Basin through Dominguez Gap.

The Los Angeles County Flood Control District is presently investigating the feasibility of constructing a barrier to prohibit sea-water intrusion in Dominguez Gap. However, impaired ground water is already present in Dominguez Gap.

Ballona Aquifer

The quality of ground water in the Ballona aquifer, which occurs in the Santa Monica Basin, has been impaired by sea-water intrusion and unregulated waste discharges to the extent that the water is considered unacceptable for most beneficial uses. As a result, there is practically no pumping of ground water from this aquifer today. Analyses of ground water from wells in the Ballona aquifer are presented in Table 4.

TABLE 4
ANALYSES OF GROUND WATER FROM SELECTED WELLS
IN THE BALLONA AQUIFER

State well number	Date sampled	Constituents in parts per million								Per- cent Na
		Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₃	TDS	
2S/15W- 1P1	8-13-54	26	20	799	1,478	103	204	0.0	2,798	92
-16F1	3- 3-54	91	60	297	108	29	708	1.0	1,251	58
-27L2	6- 6-63	276	82	3,305	606	381	4,853	0.0	9,810	86

Artesia-Exposition Aquifers

Generally, the ground water in the Artesia-Exposition aquifers is considered of good to excellent quality and acceptable for most beneficial uses according to U. S. Public Health Service standards and other water quality criteria. The only notable exception to this condition occurs in the vicinity of the community of Norwalk where the quality of ground water in the Artesia aquifer has been impaired for domestic use through improper disposal of industrial waste. Although other constituents contribute to the poor quality conditions, the presence of hydrocarbons in the water is the major problem. Even small amounts of hydrocarbons give a strong odor and bad taste to water.

During an investigation of ground water within the Norwalk area conducted by the Department in 1962, hydrocarbon pollution was determined by standard methods of evaluating the taste and odor of water pumped from wells. The estimated area in which ground water has been affected by the pollution encompasses approximately 900 acres. The major source of the pollution is believed to be petroleum wastes that have been dumped into nearby land disposal sites. Waste from these sites has introduced hydrocarbons into the Artesia aquifer which, in turn, represents a threat to the ground water quality of other aquifers in the area.

Analyses of ground water from selected wells in the Artesia-Exposition aquifers are represented in Table 5.

TABLE 5
ANALYSES OF GROUND WATER FROM SELECTED WELLS
IN THE ARTESIA-EXPOSITION AQUIFERS

State well number	Date sampled	Constituents in parts per million								Per- cent Na
		Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₃	TDS	
3S/11W-28J1	11-26-52	94	24	83	233	97	146	5.0	587	34
-30J2	7- 9-57	71	14	32	260	42	30	0.0	359	31
4S/11W- 8M1	8-23-56	40	12	40	205	24	12	0.7	347	36
- 7R2	7- 9-57	42	13	41	107	37	88	0.2	266	36
5S/12W- 2C1	5-14-62	113	12	163	113	384	194	0.0	828	52
3S/12W-18P4	9-23-53	59	13	30	252	27	16	0.4	298	23

Gage-Gardena Aquifers

Ground water from the Gage-Gardena aquifers in the area of investigation is generally acceptable for domestic and municipal uses and is considered class 1 for agricultural purposes. A few wells, particularly in the vicinity of Norwalk, extract water exceeding the acceptable quality limits for domestic use. Analyses of ground water from selected wells in the Gage-Gardena aquifers are presented in Table 6.

TABLE 6

ANALYSES OF GROUND WATER FROM SELECTED WELLS
IN THE GAGE-GARDENA AQUIFERS

State well number	Date sampled	Constituents in parts per million								Per- cent Na
		Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₃	TDS	
3S/11W-20P2	10-17-55	57	12	35	230	30	36	0.0	327	27
3S/11W-21D5	7-31-62	124	22	117	275	168	174	5.0	765	37
-28D5	12-23-58	52	9	38	212	30	31	0.5	300	32
3S/13W-10G3	8- 6-58	56	16	45	222	78	25	0.5	370	30
-13R2	5-10-55	52	9	48	228	51	22	0.0	410	39

San Pedro Formation

Ground water in the aquifers of the San Pedro Formation, which includes the Hollydale, Jefferson, Lynwood, Silverado, and Sunnyside aquifers, is generally of good to excellent quality, and is acceptable for most beneficial uses. Analyses of ground water from selected water wells in these aquifers are presented in Table 7.

The major source of impairment in these aquifers is sea-water intrusion. In the Santa Monica Basin, the Silverado aquifer has been extensively impaired as a result of sea-water intrusion. In Alamitos Gap, portions of the Lynwood aquifer, as well as the upper Pleistocene aquifers, have been impaired, as illustrated by the mineral analysis of water from the well identified by state well number 4S/12W-36M2 in Table 7. The presence of fault barriers along the east boundary of the Santa Monica Basin has prevented the intrusion of sea water into the Central and Hollywood Basins in this region. In Alamitos Gap, however, sea water has intruded aquifers of the Central Basin. To prevent continuation of this impairment, the Los Angeles County Flood Control District is currently

TABLE 7

ANALYSES OF GROUND WATER FROM SELECTED WELLS
IN THE HOLLYDALE, JEFFERSON, LYNWOOD,
SILVERADO, AND SUNNYSIDE AQUIFERS

State well number	Date sampled	Constituents in parts per million								Per- cent Na
		Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₃	TDS	
<u>Hollydale</u>										
2S/13W-36B1	1-15-64	64	16	49	234	87	37	--	389	32
3S/11W-17R1	7-24-62	69	13	39	210	62	48	0.5	380	25
3S/12W-13K1	3-25-53	68	12	27	250	47	11	1.2	312	19
<u>Jefferson</u>										
2S/12W-27C1	11-21-60	99	18	35	180	176	64	0.0	480	19
3S/11W-28L1	9- 5-54	33	8	56	194	41	17	2.0	284	51
3S/12W-13Q1	9-18-53	67	14	27	248	48	12	1.6	314	19
<u>Lynwood</u>										
2S/12W-21J1	8-16-60	66	13	37	229	62	38	2.2	449	27
3S/11W-19E2	8-15-56	53	10	22	214	26	10	1.0	260	19
3S/12W-14F1	11-25-52	109	19	37	318	85	48	0.1	476	17
3S/12W-33R4	3-16-56	46	12	25	226	19	11	1.2	253	22
4S/12W-36M2	5- 2-62	988	793	6,730	208	1,780	13,000	0.0	23,396	72
<u>Silverado</u>										
3S/11W-27G1	11- 2-62	5	3	86	166	51	16	0.2	264	88
3S/11W-15G1	8-23-56	63	40	136	384	196	97	0.9	778	47
3S/12W- 9D1	4- 4-56	61	13	34	238	41	22	10.0	326	25
4S/12W-17N1	4-30-57	21	2	56	178	2	22	--	235	66
<u>Santa Monica Basin*</u>										
2S/14W- 7P2*	4- 1-57	56	42	492	497	125	560	8.0	1,796	75
2S/15W-22E3*	4-17-62	608	317	1,284	332	791	3,140	0.0	7,116	49
2S/15W-23C4*	12-14-62	292	70	303	424	706	355	7.5	2,202	39
<u>Sunnyside</u>										
3S/12W-34F1	4-19-60	66	13	40	275	41	20	0.0	392	27
4S/12W-23K2	5- 6-57	14	2	73	193	12	20	0.0	250	77
4S/12W-28H6	8- 3-54	6	1	90	212	0	18	--	250	89

*Wells in Santa Monica Basin: Silverado and Ballona aquifers, undifferentiated.

constructing an artificial barrier to stop the inland migration of sea water through Alamitos Gap.

Quality of Imported Water

To insure a continued supply of good quality water, surface waters from the Colorado River and the Mono and Owens Basins are being imported into Southern California, including the Central, Hollywood, and Santa Monica Basins.

Imported, softened Colorado River water is sodium sulfate in character. Its total dissolved solids concentration generally exceeds 600 ppm. By comparison, imported Mono-Owens water is calcium bicarbonate in character and its total dissolved solids concentration is generally less than 250 ppm.

Average mineral analyses of treated and untreated Colorado River water and Mono-Owens water are shown in Table 8.

TABLE 8

ANALYSES OF IMPORTED WATER USED IN THE CENTRAL, HOLLYWOOD, AND SANTA MONICA BASINS

Water sampled	Constituents in parts per million								Per-
	Ca	Mg	Na+K	HCO ₃	SO ₄	Cl	NO ₃	TDS	cent Na
Untreated Colorado River water	84	28	92	167	285	83	4.4	657	38
Treated Colorado River water	52	17	51	164	285	88	4.4	678	33
Mono-Owens water	25	6	35	134	19	22	0.4	190	47

Impairment of the Quality of Ground Water

From the foregoing discussion, it is apparent that much of the ground water in the area of investigation has suffered some impairment to

its quality. Most of this impairment has resulted directly or indirectly from man's activities and must therefore be remedied by him if this valuable natural resource is to be preserved for future beneficial use.

Sources of Impairment

Although, at the present time, waste disposal practices are strictly regulated by water pollution control agencies, uncontrolled waste disposal practices in the past have impaired ground waters in the area of investigation. As mentioned previously, accompanying the industrial and urban expansion in the Los Angeles area during the 1940's and 1950's, large volumes of waste materials were discharged to the ground surface with little regard to the possible effect to the ground water. These wastes included large quantities of oil field brines that were discharged into separation ponds. From these ponds the wastes could percolate to underlying strata. Some of these wastes reached the underlying aquifers and contributed to the impairment of the ground water resources of the basins. Uncontrolled waste disposal methods have contributed significantly to the impairment of ground water in the Santa Monica Basin, in the vicinity of the community of Norwalk, in Dominguez Gap, and, to some extent, in the area adjacent to the Los Angeles River.

A potential source of impairment in all the ground water basins is decomposable refuse deposited in dumps which have since been covered. Pollution of adjacent aquifers can result during periods of high ground water levels when ground water comes in contact with the buried refuse, as well as from percolating waters passing through the buried refuse.

Although waste disposal has been a major source of impairment in the study area, sea-water intrusion has also contributed to the

impairment of the ground waters. Along the shore of the coastal plain, all the aquifers are susceptible to intrusion. However, structures of the Newport-Inglewood uplift are natural barriers to the inland migration of sea water in most of these aquifers. The major exceptions are Dominguez and Alamitos Gaps where saline waters have migrated, or threaten to migrate, into the Central Basin through Recent alluvial deposits unaffected by the uplift.

Sea-water intrusion, combined with waste disposals, has impaired ground waters in the Santa Monica Basin since about 1903 and, today, little of the ground water in the basin is beneficially used.

Methods of Protection Against Further Impairment

Although impairment to ground water quality has occurred to some degree throughout nearly all the area of investigation, large quantities of good quality ground water still remain in the aquifers of the Central, Hollywood, and Santa Monica Basins. Protection of these valuable ground water supplies from further impairment is an important factor in the full development of water resources in this region.

Efforts to protect these ground waters from further impairment include the adoption of legislation governing waste disposal methods, implementation of artificial ground water replenishment, construction of barrier projects to prevent sea-water intrusion, and formulation of construction and sealing standards for water wells.

Actions in recent years of government, industry, and private interests have brought about regulatory measures for controlling waste discharges in the study area which have help to minimize the threat to ground water quality from this source. At the present, all existing waste discharges

and those in the planning stages are subject to protective measures under the jurisdiction of the Los Angeles Regional Water Pollution Control Board. Additional water quality control is afforded by the various city and county health departments in the study area.

Methods of impeding the progress of sea-water intrusion in the study area have not, thus far, proved as successful as those for controlling waste discharges. An attempt by the Los Angeles County Flood Control District to retard the advance of sea water into the Central Basin by maintaining high ground water levels by artificial recharge methods has been only partially successful because of the large amounts of extractions of ground water for consumptive use throughout the rest of the basin.

A fresh-water barrier is presently being constructed in Alamitos Gap by the Flood Control District and should affectively halt the progress of sea-water intrusion into the basin. This barrier will consist, primarily, of a ridge of fresh water, replenished by injection wells with imported Colorado River water. A second barrier project has been considered in Dominguez Gap to restrict further encroachment of sea water in that region.

The role that improperly constructed or improperly sealed wells has played in the impairment of ground water has been significant. It is paradoxical that these wells, while intended for extracting ground water for beneficial uses, can permit the impairment of ground water quality in the aquifers from which the supply is drawn. Improperly constructed and/or improperly sealed wells provide a convenient path for impaired water to flow vertically from ground surface to the underlying aquifers, and from one aquifer to another. Although very little can be done through properly

constructed wells to halt the lateral movement of impaired water in the aquifers, the important contributing factor to ground water impairment caused by percolating surface waters and by intermixing between aquifers will be substantially reduced by adequate well sealing methods. The well construction and sealing standards presented in the following chapter are designed to permit the water wells in the Central, Hollywood, and Santa Monica Basins to continue in their beneficial role of extracting water for consumptive use and, at the same time, to keep them from contributing to the further impairment of ground water quality.

CHAPTER IV. WATER WELL STANDARDS

Water well standards are intended to prevent water quality impairment resulting from improperly constructed, defective, or inadequately destroyed wells. The standards apply not only to wells in the planning stage but also to wells presently in use that require modification, and to wells that are to be destroyed.

Recommended water well standards presented in this chapter are applicable to the specific geologic, hydrologic, and ground water quality characteristics of Central, Hollywood, and Santa Monica Basins of Los Angeles County. Certain of these well standards are applicable to all ground water-producing areas of California, so they are considered general water well standards of the State. On the other hand, to provide for conditions of ground water occurrence unique to the Central, Hollywood, and Santa Monica Basins, supplemental well standards are needed.

The general water well construction standards are presented first in this chapter, followed by a discussion of the supplemental standards, and the areas requiring these special sealing standards. The chapter is concluded with a description of the recommended sealing standards for the destruction of water wells in the area of investigation.

General Water Well Construction Standards

Recommended standards which are applicable under all the diverse conditions of ground water occurrence throughout California, together with a detailed discussion of water well construction and sealing practices in the State, are presented in Bulletin No. 74, "Recommended Minimum Well Construction and Sealing Standards for Protection of Ground Water Quality,

State of California", July 1962. These statewide standards, which are general or minimum for use in all ground water-producing areas of Los Angeles County, are summarized in the following paragraphs.

Well Location and Sanitary Requirements

Topography should be considered in selecting a well site in order to protect the well from any surface or subsurface drainage capable of impairing the quality of the ground water supply. The well should not be located near potential sources of contamination, such as sewers, cess-pools, or livestock pens.

The surface features of the water well should take into consideration prevention of bacterial contamination as well as chemical impairment. Openings, such as the connection between pump and casing or access holes to the well, should be sealed or capped.

The annular space between the casing and the side of the hole or between the conductor casing and the side of the drilled hole should be filled with cement grout or similar impervious material to prevent surface runoff or undesirable shallow ground water from entering the well. The typical surface protection features of a water well are shown in Figure 4. The annular space surface seal for deep wells should extend at least 50 feet down from the ground surface and have a minimum thickness of 1-1/2 inches. For wells 65 feet or less in depth the annular space should be sealed three-fourths of the depth of the well. Suggested methods for constructing a surface seal are presented in Appendix D.

Casing

To obtain and maintain the optimum quality of ground water and to gain the maximum operational life of the well, the proper casing should

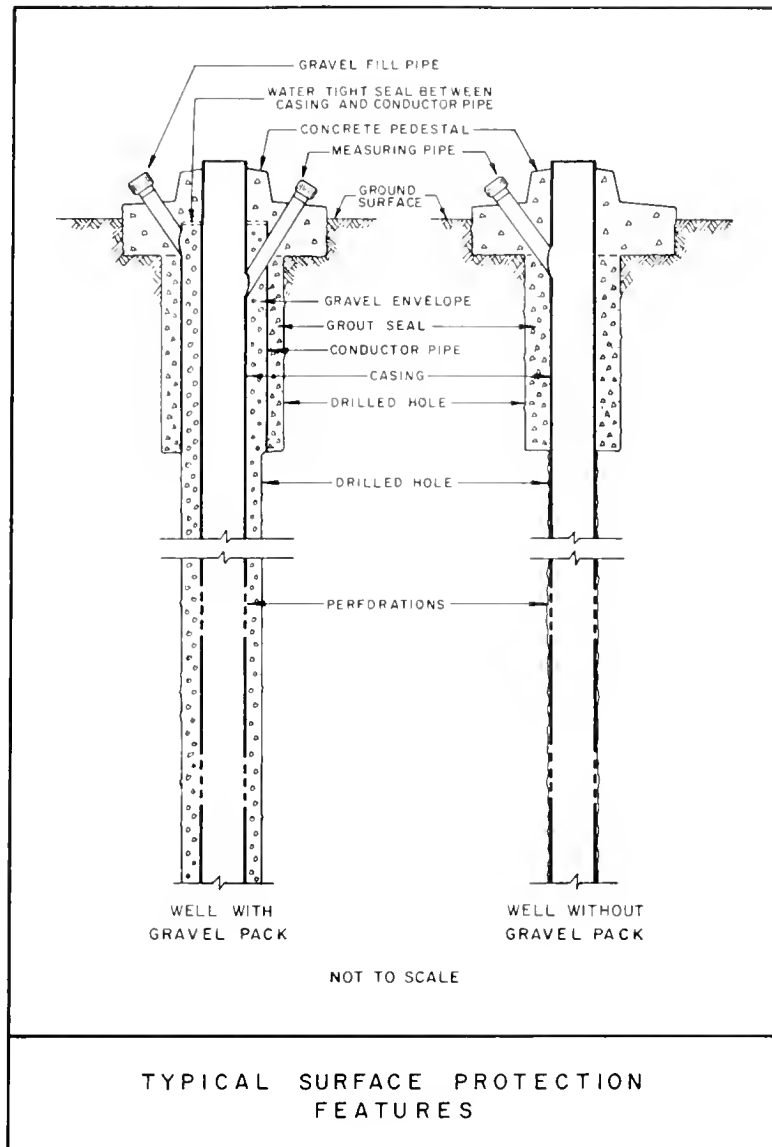


Figure 4.

be installed. The casing should be designed to withstand the forces that may act upon it during and after installation. It should also be resistant to the electrolytic and corrosive effects of earth and water.

A variety of material is used for casing. Steel is most commonly used for drilled, driven, and jetted wells, and concrete or brick for dug

wells. There is also limited use of other material such as galvanized metal, plastic, clay, and asbestos-cement. Suggestions as to the minimum thickness of steel casings are contained in Appendix E, together with a list of applicable specifications of the American Society for Testing Materials and the American Water Works Association. General specifications for concrete casing for dug wells are also presented in Appendix E.

Steel well casing and conductor pipe should not be considered to have an unlimited useful life. It should be inspected from time to time to ensure that it has not deteriorated.

Sealing-off Aquifers

Where a well penetrates more than one aquifer and the water in one or more of the aquifers is of unsatisfactory quality or becomes unsatisfactory after the well is constructed, the aquifers which contain the unsatisfactory water should be sealed off to prevent entrance of such water into the well or other aquifer. Sufficient sealing material should be applied to fill the annular space between the casing and the wall of the drilled hole in the interval to be sealed, and to fill the voids which might absorb the sealing material. The sealing material should be placed from the bottom to the top of the interval to be sealed. Sealing should be accomplished by a method which has been approved by the enforcing agency. Recommended sealing materials and methods for sealing-off aquifers are presented in Appendix D.

Well Development

Developing, redeveloping, or conditioning of a well should be done with care and by methods which will not cause damage to the well or destroy barriers to the vertical movement of water between aquifers. The

latter recommendation is particularly applicable where the quality of water in one of the aquifers has been degraded. These barriers or seals may be disturbed or destroyed by "overdevelopment". This occurs through excessive bailing or pumping of fines from the formation, creating caverns in the aquifer adjacent to the casing.

Water Quality Sampling

To determine the quality of ground water that will be available from the well and the suitability of the water for intended uses, it is recommended that the water in all wells be sampled immediately following construction and development, and appropriate analyses based upon intended uses be made. It may also be advisable to take samples of water during construction, especially when local aquifers are suspected to have water of impaired quality. These analyses would serve as guides in locating casing perforations and seals.

Supplemental Water Well Construction Standards

Water quality problems and the conditions of ground water occurrence in portions of the Central, Hollywood, and Santa Monica Basins require that, in some areas, the general minimum statewide water well standards be supplemented to protect water quality from impairment by improperly constructed or sealed wells. Typically, the deeper aquifers of the study area contain better quality water than the shallower aquifers. Where the quality of water is so poor that it presents a threat of impairment, necessary measures must be taken to seal off the upper aquifers in water wells to keep the impaired water from moving into the lower aquifers. Accordingly, additional standards have been developed to meet those needs.

Based on the characteristics of ground water occurrence, and water quality conditions as determined during this study, the Central, Hollywood, and Santa Monica Basins have been separated into five areas, or zones, as shown on Plate 6, "Areas of Recommended Sealing Standards".

Central, Hollywood, and Santa Monica Basins
Recharge Areas (Zone I)

Those portions of the study area in which the Bellflower aquiclude is absent, or where the base of the Bellflower aquiclude is less than 50 feet below the ground surface, are included in Zone I, as designated on Plate 6. This includes all of Santa Monica and Hollywood Basins, and nearly all of the Los Angeles and Montebello Forebays, as well as the Whittier Area in the Central Basin.

Where the Bellflower aquiclude is absent, water can percolate from the ground surface to the ground water in the underlying aquifers. Water well construction methods that provide a surface seal to prevent the entrance of surface water into the underlying aquifers through the well opening should be employed under these conditions. Where the base of the Bellflower aquiclude is less than 50 feet in depth, the minimum surface seal will essentially restore the protective qualities of the aquiclude. Therefore, for Zone I, the general water well construction and sealing standards are recommended as the minimum requirement.

Inland Plains Area (Zones II-V)

That part of the Central Basin in which the Bellflower aquiclude is greater than 50 feet in thickness is referred to in this report as the "Inland Plains Area". It includes the Central Basin Pressure Area and portions of the Los Angeles and Montebello Forebays. To protect the

quality of the ground water in the underlying aquifers, the surface seal should extend at least to the base of the Bellflower aquiclude so that the natural protection from percolating surface waters provided by the aquiclude will be maintained. However, in three separate parts of the Inland Plains Area, poor quality water present in some of the aquifers requires additional supplementary water well sealing requirements.

Accordingly, the Inland Plains Area contains four of the five zones shown on Plate 6. These include: Downey Plain Area -- Zone II; Dominguez Gap -- Zone III; Norwalk Area -- Zone IV; and Alamitos Gap -- Zone V. The ground water quality conditions in each zone and the specific water well sealing requirements needed will be described in the following paragraphs.

Downey Plain Area -- Zone II. The portion of the Inland Plains Area that generally coincides with the Downey Plain is underlain (except for semiperched waters) by ground water of good quality. This area is designated on Plate 6 as Zone II. In this area, maintaining the protection provided by the Bellflower aquiclude is the only special consideration in the construction and sealing of water wells. Therefore, for the construction and sealing of water wells in Zone II, in addition to the general standards, it is recommended that the surface seal extend from the base of the Bellflower aquiclude to the ground surface. The elevation of the base for a specific well location in Zone II may be determined from Plate 5.

Dominguez Gap -- Zone III. Within the inland segment of Dominguez Gap, the ground water in the Gaspur aquifer decreases in quality southwest-erly with water from wells near the basin boundary in the gap containing

more than 900 ppm total dissolved solids. It is suspected that the main cause of this impairment has been the disposal of oil brine wastes in the area. Moreover, with the continued use of the oil disposal sites, this source of impairment still exists. The estimated areal extent of degraded ground waters containing total dissolved solids in concentration in excess of 700 ppm, in the Gaspur aquifer is shown on Plate 7, "Water Well Sealing Zone -- Dominguez Gap".

The aquifers underlying the Gaspur aquifer in the Dominguez Gap area contain ground water of good to excellent quality. These waters could be impaired by downward movement of the poor quality water by way of inadequately sealed water wells. Consequently, sealing standards supplementary to the general statewide standards are needed to protect these underlying aquifers. The area in which this protection is estimated to be needed is designated in Zone III.

Under present conditions, a slight inland ground water gradient exists that may allow the impaired water at Dominguez Gap to move further inland. Although the rate of travel of this impaired water would be slow, it must be recognized that as long as present conditions continue, the impaired water may affect a larger area. Anticipating this possibility, a mile-wide peripheral area inland of the area presently containing waters with total dissolved solids in excess of 700 ppm has been included in Zone III, the region calling for these specific sealing recommendations. It is estimated that the impaired water will not extend further inland than 1 mile. However, should the impaired water move beyond the estimated limit, the 1-mile peripheral area should provide ample time to prepare the necessary revisions in the zone boundary.

Any water well that penetrates aquifers below the Gaspar aquifer in Zone III should seal off the Gaspar to protect the underlying aquifers. To accomplish this, it is recommended that an annular space seal extend from at least 20 feet below the base of the Gaspar aquifer to the ground surface. Elevations on the base of the Gaspar in the vicinity of Dominguez Gap are shown on Plate 7. Water wells which extend only to the Gaspar aquifer within Zone III should provide a surface seal to the base of the Bellflower aquiclude as described for Zone II to prevent further deterioration to the ground water.

Norwalk Area -- Zone IV. As discussed in Chapter III, the quality of the water in the Artesia aquifer in the vicinity of Norwalk has been adversely affected by hydrocarbon pollution. The estimated boundaries of the area in which ground water has been affected by the pollution (encompassing 900 acres) are shown on Plate 8, "Water Well Sealing Zone IV -- Norwalk Area". Zone IV is that area for which it is estimated that water well construction methods and sealing requirements will need to provide protection for the water in the Artesia aquifer from further deterioration and to protect the underlying aquifers from downward movement of the polluted water in the Artesia aquifer.

To provide the needed protection, supplementary surface seal standards in addition to the general water well standards are required in Zone IV. Water wells which extend only to the Artesia aquifer should provide a surface seal to the base of the Bellflower aquiclude as described for Zone II.

Water wells which penetrate aquifers underlying the Artesia aquifer should seal off the Artesia to prevent polluted water from moving

downward into those aquifers. To accomplish this, it is recommended the surface seal extend to at least 20 feet below the base of the Artesia aquifer. The elevation of the base of the Artesia aquifer underlying Zone IV is shown on Plate 8.

The portion of Zone IV outside the suspected area of polluted water is based on anticipated future lateral movement of the polluted water. It should be pointed out that the variability of the factors affecting this movement makes the amount and direction of movement difficult to predict. It depends primarily upon the direction and magnitude of the hydraulic gradient. The gradient from the polluted area was westward until 1963, as a result of a pumping depression immediately west of the area. Presently, the depression no longer exists, and the direction of ground water movement is southward. Estimates of the potential rate of movement range considerably: as little as 600 feet per year, and as much as 4,000 feet per year.

Alamitos Gap -- Zone V. As pointed out in Chapter II, the water levels in the Central Basin have been drawn below sea level, thereby allowing sea water to move inland through Alamitos Gap. The saline waters have reached the Central Basin primarily by way of the unlined Los Cerritos Tidal Channel and through the coarse basal Recent deposits in the gap. The Seal Beach fault in Alamitos Gap is an effective barrier that prevents sea water from moving directly into the Pleistocene aquifers of the Central Basin. However, the Lynwood, Gage, and Artesia aquifers are exposed to the coarse basal gravels of the Recent deposits on the Central Basin, or inland, side of the fault. This structural relationship is illustrated by Section G-G' on Plate 3B. Because of this hydraulic continuity, sea

water that has intruded the Recent materials of Alamitos Gap has also been able to move into these Pleistocene aquifers. The inland extent of sea-water impairment in these aquifers, in spring 1963, based on waters containing chlorides in concentration in excess of 500 ppm is shown on Plate 9, "Water Well Sealing Zone V -- Alamitos Gap".

Although the Silverado and Sunnyside aquifers are separated from these saline waters by relatively impermeable sediments, water quality impairment could occur by downward movement of the saline water in the overlying aquifers through improperly constructed wells. To prevent such impairment to the ground water quality in these deeper aquifers, supplemental water well construction and sealing standards, in addition to the general statewide standards, are necessary for the Alamitos Gap area, designated Zone V.

Therefore, the construction of water wells that penetrate deeper than the Lynwood aquifer (the deepest aquifer susceptible to saline-water intrusion) in Zone V should provide an annular seal that extends from the ground surface to at least 20 feet below the base of the Lynwood aquifer. This annular seal is to protect the quality of water in the Silverado and underlying aquifers from impairment by the downward movement of saline water present in the overlying aquifers.

In addition to the minimum general water well standards, wells in Zone V that penetrate no deeper than to the base of the Lynwood aquifer should be provided a surface seal to the base of the Bellflower aquiclude. The ground waters in these aquifers have all been impaired by sea-water intrusion to some degree, and special water well construction standards would not protect them from this source of impairment. However, protection

from further deterioration by way of percolating surface waters warrants a surface seal as described for Zone II.

The areal extent of Zone V, for which these supplementary water well standards are recommended, was determined from a review of the Alamitos Gap Project and an evaluation of its effect on saline waters in the gap. The Alamitos Gap Project is a cooperative program between the Los Angeles County Flood Control District and the Orange County Water District. The program is to develop a pressure ridge across Alamitos Gap that will serve as a barrier to further intrusion of saline water.

The barrier consists of a series of injection wells, whose alignment is shown on Plate 9. The first of these wells is presently being constructed by the Los Angeles County Flood Control District. Imported fresh water will be used in the injection wells to build up the pressure ridge. However, the barrier will be seaward of the inland extent of the presently intruded saline water. As a result, a wedge of saline water will be pinched-off inland of the barrier. This wedge of saline water will probably move further inland. Although the future behavior and disposition of this wedge of saline water cannot be predicted accurately, estimates may be made from the experience developed at the West Coast Basin Barrier Project in Manhattan Beach, California, and from experiments conducted by the University of California at Berkeley. Eventually, the saline wedge may be dispersed through commingling with the injected fresh water. However, until the wedge dispersion is complete, it could cause some degree of temporary degradation of the quality of water in the Silverado and underlying aquifers.

Data from the barrier operation in Manhattan Beach indicate the pinched-off saline wedge in that area began to dissipate 7,000 to 8,000 feet

inland of the line of injection wells. The general geologic and hydraulic characteristics of the Manhattan Beach and Alamitos Gap areas are enough alike to expect the saline wedges to behave similarly.

Should the wedge not dissipate, but instead move inland at a rate of 500 feet per year (a probable maximum rate of movement), it will take eight years for the wedge to reach the boundary of Zone V. This should provide sufficient time after the barrier in Alamitos Gap is in operation to review the adequacy of the recommended sealing standards and the zone delineation.

Water Well Destruction Standards

A well that no longer serves a useful purpose or has fallen into such a state of disuse and disrepair that it may become a source of impairment to ground water quality should be destroyed in a manner that will prevent such impairment. Basically, a seal is constructed in the well to prevent the impaired waters reaching good quality ground water via the water well. The following procedures are considered minimum sealing standards and should be supplemented, as conditions warrant, to restore, as nearly as possible, the protection to the ground water provided by the geologic conditions that existed prior to construction of the well. The typical features of a properly destroyed water well are shown in Figure 5.

The standards for proper destruction of water wells in the Central, Hollywood, and Santa Monica Basins may be subdivided into general standards and supplemental standards as was done for the standards for water well construction. General standards are valid for all ground water-producing areas in California, whereas supplemental standards are provided to meet the needs of specific conditions of ground water occurrence in the Central, Hollywood, and Santa Monica Basins.

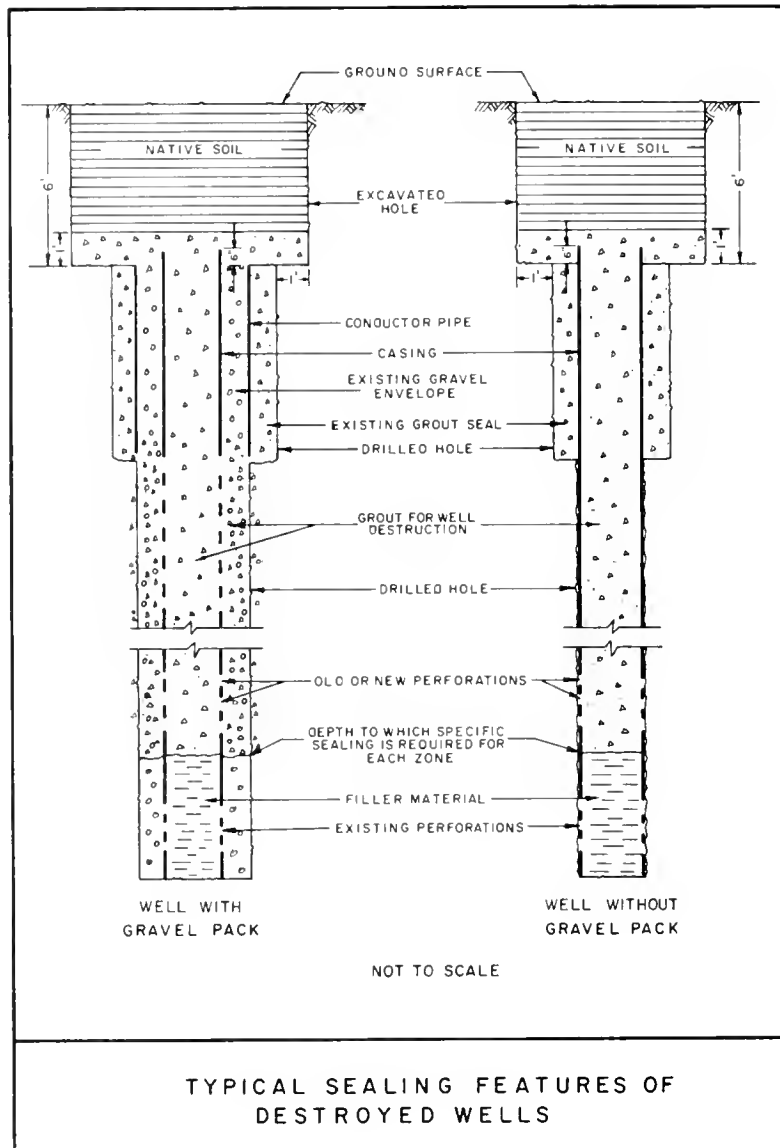


Figure 5

General Water Well Destruction Standards

When a well is to be destroyed, the interior of the casing should first be cleaned out to eliminate any obstructions which might interfere with effective sealing procedures. The open well should then be filled with impervious filler material from the bottom of the well up to the

recommended depth of the sealed zone. The filler material may be portland cement grout, impervious native soil, clay, or other suitable impervious material.

The sealed zone, as mentioned above, is provided to prevent impaired waters from commingling with good quality water. It is recommended that such a seal extend to a depth of at least 50 feet below the surface and should be greater when conditions warrant it. Recommended materials to be used for a seal are described in Appendix D.

Sealing material should be placed in the well casing in the interval to be sealed and, if needed, in the annular space surrounding the casing. Gravel-packed wells require sealing of the annular space. To be sure that the annular spaces adjacent to clay layers are sealed, it is often necessary to rip or perforate the casing to allow fluid sealing material to reach the space from the well shaft. Procedures to follow to insure an adequate seal are:

1. If there is an annular space or if its occurrence between the drilled hole and the well casing is unknown, sealing material should be applied through rips or perforations in the well casing by a pressure grouting method to seal the annular space, until grout returns to the ground surface through the annular space between the drilled hole and the well casing.

2. If an annular space exists between the drilled hole and the conductor pipe, it should also be sealed. Sealing material should be applied by means of a grout pipe set near the bottom of the annular space. If the annular space is restricted, the grouting pipe may be jetted in place.

3. If a well does not have an annular space between the drilled hole and the casing, the casing should be filled with sealing material to the top of the casing using a dump bailer, grouting pipe, or similar means. The sealing material should be applied continuously, beginning at the top of the filler material and moving upward to the top of the well casing.

4. If the annular space of a well has previously been sealed with a sealing material, such as portland cement grout, during well construction, the seal need not be disturbed. However, if possible, the seal should be inspected to ensure that it conforms with the standards presented in this report.

5. For the protection of the seal and to facilitate the future use of the well site, a hole should be excavated around the well casing to a depth of 6 feet below the ground surface and the well casing removed to just above this depth. The sealing material used to fill the well should be allowed to spill over into the excavation and form a cap at least 1 foot thick. After the sealing material has set, the excavation should be filled with native soil as shown on Figure 5.

Supplemental Water Well Destruction Standards

In portions of the area of investigation, supplemental standards, in addition to the general standards described above, are needed to ensure the protection of the quality of ground water when destroying a water well. These supplemental standards are concerned with sealing off the aquifers that have been identified in each zone to contain ground water of impaired quality, and to restore, as nearly as possible, the imperviousness that had been provided by the Bellflower aquiclude.

In Zone I, therefore, where ground water is essentially unconfined or where the surface clays are thin, the minimum general standards which provide for a seal to a 50-foot depth are sufficient. In Zone II, however, in addition to the minimum general standards, the seal should extend to the base of the Bellflower aquiclude.

The depth of the seal for proper destruction of water wells located in Zones III, IV, or V depends on the aquifers penetrated by the well. In Zone III, for example, if the well extends below the Gaspur aquifer, the depth of the seal should be at least 20 feet below the Gaspur. On the other hand, wells that penetrate only the Gaspur aquifer should have a seal to the base of the Bellflower aquiclude.

Proper destruction of water wells in Zone IV depends on whether the well penetrates below the Artesia aquifer or not: wells to be destroyed that penetrate aquifers below the Artesia should have a seal to a depth of at least 20 feet below the Artesia, and wells that are no deeper than the Artesia aquifer should have a seal to the base of the Bellflower aquiclude.

In Zone V, similar criteria are used to determine the depth of the seal for wells to be destroyed. In this area, the depth of the well in relation to the Lynwood aquifer is the primary factor. Therefore, in the destruction of wells in Zone V, wells that are deeper than the Lynwood should at least provide a seal that extends 20 feet deeper than the base of the Lynwood, and wells that are not deeper than the Lynwood aquifer need only have a seal to the base of the Bellflower aquiclude.

CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations have resulted from this investigation of standards for water well construction and sealing in the Central, Hollywood, and Santa Monica Basins.

Conclusions

1. Ground water is an important part of the water supply of the Central, Hollywood, and Santa Monica Basins.
2. With few exceptions, the aquifers that occur within the Central, Hollywood, and Santa Monica Basins contain waters of good quality.
3. The water that occurs in the Semiperched and Ballona aquifers is generally unacceptable for beneficial use.
4. In three areas, the quality of ground water in the shallow aquifers has been impaired through intrusion of sea water and/or the indiscriminate disposal of industrial wastes. These areas include: Dominguez Gap, in which the quality of water in the Gaspar aquifer has been impaired by disposal of oil brine wastes; Alamitos Gap, where sea water has moved inland to impair ground water in the Lynwood and overlying aquifers; and Norwalk area, where uncontrolled disposal of oil brine wastes has allowed hydrocarbons to commingle with ground waters in the Artesia aquifer.
5. The commingling of ground waters between aquifers does not occur except where the aquifers are merged or where faulty well construction or destruction permits short circuiting of ground waters.
6. Wells that are improperly constructed or improperly destroyed may act as conduits and transmit water of impaired quality from the ground surface to the deeper aquifers containing water of unimpaired quality.

7. There are five areas in the basins studied in which the conditions of ground water occurrence call for specific water well standards to provide for adequate protection of the quality of the water. These areas are: Zone I, which includes all of the Hollywood and Santa Monica Basins as well as the Central Basin recharge areas, where the minimum general standards are sufficient; and Zones II through V, which are all areas in which shallow aquifers contain ground waters of impaired quality.

8. The boundaries of each zone define the present or potential lateral extent of impaired ground waters in that zone.

9. Compliance with the water well standards set forth in this report will deter impairment to the ground water quality by improperly constructed or destroyed wells.

Recommendations

It is recommended that:

1. The Los Angeles Regional Water Pollution Control Board, local agencies, local water producers, and water well drillers adopt the standards presented in Bulletin No. 74 and in this bulletin and apply them in a manner that will assist in preserving and improving the quality of the common ground water supply.

2. Further movement of the impaired ground water in Zones III, IV, and V should be kept under surveillance by regular monitoring of the quality of water in wells on the periphery of the zones.

APPENDIX A

BIBLIOGRAPHY

APPENDIX A

BIBLIOGRAPHY

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APPENDIX B

WATER QUALITY CRITERIA

APPENDIX B

WATER QUALITY CRITERIA

Criteria presented in the following sections can be utilized in evaluating mineral quality of water relative to existing or anticipated beneficial uses. It should be noted that these criteria are merely guides to the appraisal of water quality. Except for those constituents which are considered toxic to human beings, these criteria should be considered as suggested limiting values. Water which exceeds one or more of these limiting values need not be eliminated from consideration as a source of supply, but other sources of better quality water should be investigated.

Drinking Water Criteria

Criteria for appraising the suitability of water for domestic and municipal use in connection with interstate quarantine have been promulgated by the United States Public Health Service. The limiting concentrations of chemical substances in drinking water have been abstracted from these criteria and are shown in Table B-1. Other organic or mineral substances may be limited if their presence renders the water hazardous for use.

Interim standards for certain mineral constituents have been adopted by the California State Board of Public Health. Based on these standards, temporary permits may be issued for drinking water supplied failing to meet the United States Public Health Service Drinking Water Standards, provided the mineral constituents in Table B-2 are not exceeded.

TABLE B-1

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1962

Dissolved constituent	:Concentration which: :constitutes grounds: : for rejection* :	Recommended maximum concentration*
Arsenic (As)	0.05	0.01
Barium (Ba)	1.0	
Cadium (Cd)	0.01	
Chromium (Hexavalent) (Cr ⁺⁶)	0.05	
Cyanide (CN)	0.2	0.01
Lead (Pb)	0.05	
Selenium (Se)	0.01	
Silver (Ag)	0.05	
Chloride (Cl)		250.0
Copper (Cu)		1.0
Iron (Fe)		0.3
Manganese (Mn)		0.05
Nitrate (NO ₃)		45.0
Sulfate (SO ₄)		250.0
Zinc (Zn)		5.0
Phenols		0.001
Total dissolved solids, desirable		500.0
Alkyl Benzene Sulfonate		0.5
Carbon Chloroform Extract (CCE)		0.2

*Concentrations of the dissolved constituents in water are expressed in parts per million by weight.

TABLE B-2

UPPER LIMITS OF TOTAL SOLIDS AND SELECTED MINERALS
IN DRINKING WATER AS DELIVERED TO THE CONSUMER

In parts per million

Constituent	Permit	Temporary permit
Total solids	500 (1,000)*	1,500
Sulfates (SO ₄)	250 (500)*	600
Chlorides (Cl)	250 (500)*	600
Magnesium (Mg)	125 (125)	150

*Numbers in parentheses are maximum permissible, to be used only where no other more suitable water is available in sufficient quantity for use in the system.

The California State Board of Public Health has defined the maximum safe amounts of fluoride ion in drinking water in relation to mean annual temperature. These relationships are shown in Table B-3.

TABLE B-3

RELATIONSHIP OF TEMPERATURE TO FLUORIDE
CONCENTRATION IN DRINKING WATER

Mean annual temperature	Mean monthly fluoride ion concentration, in parts per million
50° F	1.5
60° F	1.0
70° F - above	0.7

Criteria for Hardness

Even though hardness in water is not included in the foregoing standards, it is important to domestic and industrial uses. Excessive hardness in water used for domestic purposes causes increased consumption

of soap and formation of scale in pipe and fixtures. Table B-4, which shows degrees of hardness in water, has been suggested by the United States Geological Survey.

TABLE B-4

HARDNESS CLASSIFICATION

Range of hardness expressed as CaCO ₃ , in parts per million	:	Relative classification
100 or less	:	Soft
101 to 200	:	Moderately hard
Greater than 200	:	Very hard (usually requires softening)

Criteria for Irrigation Water

Criteria for mineral quality of irrigation water have been developed by the Regional Salinity Laboratories of the United States Department of Agriculture in cooperation with the University of California. Because of diverse climatological conditions and the variation in crops and soils in California, only general limits of quality for irrigation waters can be suggested. The Department uses three broad classifications of irrigation waters as listed below and in Table B-5.

Class 1 - Regarded as safe and suitable for most plants under most conditions of soil and climate.

Class 2 - Regarded as possibly harmful for certain crops under certain conditions of soil or climate, particularly in the higher ranges of this class.

Class 3 - Regarded as probably harmful to most crops and unsatisfactory for all but the most tolerant.

These criteria have limitations in actual practice. In many instances, water may be wholly unsuitable for irrigation under certain conditions of use, and yet be completely satisfactory under other

circumstances. Consideration also should be given to soil permeability, drainage, temperature, humidity, rainfall, and other conditions that can alter the response of crop to a particular quality of water.

TABLE B-5

QUALITATIVE CLASSIFICATION OF IRRIGATION WATERS

	: Class 1	: Class 2	: Class 3
Chemical properties	: Excellent	: Good to	: Injurious to
	: to good	: injurious	:unsatisfactory
Total dissolved solids, in ppm	Less than 700	700 - 2,000	More than 2,000
Conductance, in micromhos at 25° C	Less than 1,000	1,000 - 3,000	More than 3,000
Chlorides, in ppm	Less than 175	175 - 350	More than 350
Sodium, in percent of base constituents	Less than 60	60 - 75	More than 75
Boron, in ppm	Less than 0.5	0.5 - 2.0	More than 2.0

Criteria for Industrial Uses

It is beyond the scope of this report to present water quality requirements for the numerous types of industry found in Los Angeles County or for the diverse processes within these industries, because such criteria are as varied as industry itself. Food processing, beverage production, pulp and paper manufacturing, and textile industries have exacting requirements, while poor quality water can be used for some cooling or metallurgical operations. In general, where a water supply meets drinking water standards, it is satisfactory for industrial use, either directly or following a limited amount of treatment or softening by the industry.

APPENDIX C

WELL NUMBERING SYSTEM

APPENDIX C

WELL NUMBERING SYSTEM

The state well numbering system used in this report is based on township, range, and section subdivision of the Public Land Survey. It is the system used in all ground water investigations and for numbering all wells for which data are published or filed by the Department of Water Resources. In this report the number of a well, assigned in accordance with this system, is referred to as the state well number.

Under the system each section is divided into 40-acre tracts lettered as follows:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Note that I and O are omitted in the grid above.

Wells are numbered within each 40-acre tract according to the chronological sequence in which they have been assigned state well numbers. For example, a well which has the number 9N/32W-17G1, S, would be in Township 9 North, Range 32 West, Section 17, San Bernardino Base and Meridian, and would be further designated as the first well assigned a state well number in tract G. Well numbers are referenced to the Humboldt Base and Meridian (H), the Mount Diablo Base and Meridian (M), or the San Bernardino Base and Meridian (S).

APPENDIX D

SUGGESTED METHODS FOR PROVIDING A SURFACE SEAL AND FOR SEALING OFF AQUIFERS

APPENDIX D

SUGGESTED METHODS FOR PROVIDING A SURFACE SEAL AND FOR SEALING OFF AQUIFERS

Following are listed several methods for sealing the upper portion of the annular space (the "surface" or "sanitary seal") and for sealing off aquifers containing undesirable water.

General

1. No drilling operations or associated work in the well should be conducted for at least 24 hours, and preferably 72 hours, after sealing operations have been completed.
2. Before installing or reinstalling the pump assembly, the well casing should be inspected and cleaned out if necessary.
3. Cement grout used in sealing should consist of not more than one or two parts of sand to one part of cement, and not more than six gallons of water per sack of cement. Admixtures should not exceed 10 percent of the volume of cement. Neat cement (cement and water only) is preferred over other grouts, as it eliminates the possibility of separation of sand and cement during placement. A good neat cement grout mix will consist of five gallons of water per sack of cement.

Sealing the Upper Portion of the Annular Space

The following methods can be used to provide a sanitary, or surface, seal and for sealing off upper aquifers containing water of undesirable quality. The seal is placed in the annular space between the drilled hole and either the well casing or conductor pipe.

Grouting Pipe Method

In this method, a seal is placed in the annular space from the bottom up through a grout pipe suspended in the annular space.

1. Drill the hole large enough in the interval to be sealed so that an annular space will exist between the casing and the conductor pipe (providing the conductor pipe is to be pulled) or between the conductor pipe and the hole if the conductor pipe is to remain in the hole.

2. So that grout will not get into the well, you may have to provide a grout retainer in the annular space below the interval to be sealed.

3. Extend the grouting pipe down the annular space to the bottom of the interval to be sealed.

4. Add grout through the grouting pipe in one continuous operation. Be sure the grouting pipe remains submerged in the grout during the placement of the seal. If the conductor pipe is to be pulled, do this as the annular space is filled with grout.

If the annular space is restricted or no conductor pipe is used, you may have to jet the grout pipe to the required depth.

Pressure Cap Method

In the pressure cap method, the grout is placed in the bottom of the hole through a grout pipe set inside the casing.

1. Suspend the casing or other inner pipe about 2 feet above the bottom of the drilled hole and fill with water.

2. Place a pressure cap over the casing and extend a grout pipe through the cap and casing to the bottom of the hole.

3. Force the grout through the pipe, up into the annular space around the outside of the casing, to the ground surface.

4. Lower the casing and seal it into its permanent position after the grout is in place.

5. When the grout has set, remove the plug formed during grouting and continue drilling the rest of the well.

Dump Bailer Method

In the dump bailer method, the grouting is done with the hole drilled only slightly below the bottom of the casing, and drilling is completed after the grout is in place and set.

1. Place enough impervious grout in the casing to fill the lower 20 to 40 feet of the hole by lowering a bailer filled with grout into the casing and opening the bottom valve which dumps the load of grout at the desired level.

2. Raise the casing 20 to 40 feet with the bottom of the casing remaining in the grout.

3. Fill the casing with water and cap, and then lower the water-filled casing to the bottom of the hole. This action should force the grout up the annular space between the casing and the drilled hole. Be sure the casing remains capped until the grout is set. If you anticipate that there will be difficulty in maneuvering the capped, water-filled casing, you can put water in on top of the grout without lifting the casing. Continue to add water to the casing until a quantity equal to the volume of grout has been put in. This should force most of the grout out of the lower end of the casing.

4. When the grout is set, drill through the hardened cement in the lower end of the casing and continue drilling the well.

Sealing Off Aquifers

The following methods can be used in sealing off aquifers or zones.

Pressure Grouting Method

This method can be employed where an annular space exists between the well casing and the wall of the drilled hole.

1. Perforate the casing opposite the interval to be sealed.
2. Place a packer, plug, or other sealing device in the casing at or below the bottom of the perforated interval.
3. Place grout in the casing opposite the interval to be sealed by means of a dump bailer or grout pipe.
4. Place a packer or other means of sealing the casing above the perforations.
5. Apply pressure to the packer to force the grout through the perforations into the interval to be sealed.
6. Maintain pressure until the material has set.
7. Drill out the packer and other material remaining in the well.

Liner Method

Where an annular space does not exist between the well casing and the wall of the drilled hole, the liner method can be employed.

1. Place a smaller diameter metal liner inside the original casing opposite the perforated interval to be sealed, and extend it at least 10 feet above and below the perforated interval.
2. Provide a grout-retaining seal at the bottom of the annular space between the liner and the well casing.

3. Extend the grouting pipe to the top opening between the liner and casing, and fill the annular space between the well casing and the liner with grout in one continuous operation.

4. Be sure the grouting pipe remains submerged in the sealing material during the entire time it is being placed.

Where corrosion is not a problem, a liner with malleable metal sections at both ends may be swaged tightly against the casing to form a watertight seal.

APPENDIX E

CASING REQUIREMENTS FOR DRILLED AND DUG WELLS

APPENDIX E

CASING REQUIREMENTS FOR DRILLED AND DUG WELLS

To obtain and maintain the optimum quality of ground water and to gain the maximum operational life of a well, the proper casing should be installed. The casing should be designed to withstand the forces that may act upon it during and after installation.

Because the majority of water wells are drilled or dug, casing criteria for only these two types of wells are discussed in the following sections. In addition, notes on drive shoe and placement of casing are presented.

Casing Material for Drilled Wells

Steel used in manufacturing the water well casing should be weldable and should meet one of the following American Society for Testing Materials (ASTM) specifications, or the requirements for steel manufacture incorporated under the water well casing fabrication specifications, including the latest revisions thereof:

1. American Society for Testing Materials (ASTM A7).
"Tentative Specifications for Steel for Bridges and Buildings."
2. American Society for Testing Materials (ASTM A245).
"Tentative Specifications for Flat Rolled Carbon Steel Sheets of Structural Quality."
3. American Society for Testing Materials (ASTM A283D).
"Standard Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (Plate 2 Inches and Under in Thickness)."
4. American Society for Testing Materials (ASTM A373).
"Tentative Specifications for Structural Steel for Welding."

Fabrication of Casing Material

The casing should be fabricated according to the latest revision of one of the following specifications:

1. American Petroleum Institute (API Std. 5L).
"Specifications for Line Pipe."
2. American Society for Testing Materials (ASTM A53).
"Tentative Specifications for Welded and Seamless Steel Pipe."
3. American Society for Testing Materials (ASTM A134).
"Standard Specifications for Electric-Fusion (Arc)-Welded Steel Pipe (Sizes 16 Inches and Over)."
4. American Society for Testing Materials (ASTM A135).
"Tentative Specifications for Electric-Resistance-Welded Steel Pipe."
5. American Society for Testing Materials (ASTM A139).
"Standard Specifications for Electric-Fusion (Arc)-Welded Steel Pipe (Sizes 4 Inches and Over)."
6. American Society for Testing Materials (ASTM A211).
"Standard Specifications for Spiral-Welded Steel or Iron Pipe."
7. American Water Works Association (AWWA C201).
"Tentative Standard for Fabricated Electrically Welded Steel Pipe."
8. American Water Works Association (AWWA C202).
"Tentative Standard for Fabricated Electrically Welded Steel Pipe."

Casing Thickness for Drilled Wells

Steel casing equal to or exceeding the thickness given in the following tabulation should be used for permanent installation in water wells:

MINIMUM THICKNESS FOR STEEL WATER WELL CASING
FOR DRILLED WELLS SINGLE CASING

Depth of casing, in feet	<u>Diameter, in inches</u>										
	<u>6</u>	<u>8</u>	<u>10</u>	<u>12</u>	<u>14</u>	<u>16</u>	<u>18</u>	<u>20</u>	<u>22</u>	<u>24</u>	<u>30</u>
0-100	12	12	10	10	8	8	1/4	1/4	1/4	1/4	5/16
100-200	12	10	10	8	8	3/16	1/4	1/4	1/4	1/4	5/16
200-300	10	10	8	8	1/4	1/4	1/4	1/4	5/16	5/16	5/16
300-400	10	8	8	3/16	1/4	1/4	1/4	5/16	5/16	5/16	3/8
400-600	10	8	3/16	1/4	1/4	5/16	5/16	5/16	5/16	3/8	3/8
600-800	3/16	3/16	1/4	1/4	5/16	5/16	3/8	3/8	7/16	7/16	7/16
Over 800	1/4	1/4	1/4	5/16	5/16	3/8	3/8	7/16	7/16	1/2	1/2

Values above diagonal are United States Standard gage.
Values below diagonal are thickness in inches.

MINIMUM THICKNESS FOR STEEL WATER WELL CASING FOR
DRILLED WELLS DOUBLE CASING
(CALIFORNIA STOVEPIPE)

	<u>Diameter, in inches</u>								
<u>Depth of casing, in feet</u>	<u>10</u>	<u>12</u>	<u>14</u>	<u>16</u>	<u>18</u>	<u>20</u>	<u>22</u>	<u>24</u>	<u>30</u>
0-100	12	12	12	12	10	10	10	10	8
100-200	12	12	12	10	10	10	10	8	8
200-300	12	12	10	10	10	10	8	8	8
300-400	12	12	10	10	10	8	8	8	8
400-600	10	10	10	10	8	8	8	8	8
600-800	10	10	10	8	8	8	8	8	8
Over 800	10	8	8	8	8	8	8	8	8

Values given are United States Standard gage.

Casing Material for Dug Wells

Either steel or concrete should be used for casing in dug wells.
Steel used in the manufacture of casing for dug wells should conform to the same specifications for casing material previously described under drilled wells, and the thickness should conform to the following specification:

MINIMUM THICKNESS OF STEEL
CASING FOR DUG WELLS

<u>Outside diameter, in inches</u>	<u>Minimum U. S. Standard gage or plate thickness</u>
24	8 gage
30	3/16 inch
36	3/16 inch
42	1/4 inch
48	1/4 inch

When concrete casing is used, it should either be poured in place, or consist of precast concrete rings. The poured-in-place concrete should be sufficiently strong to withstand the earth and water pressures imposed on it. It should be properly reinforced with steel to furnish tensile strength and to resist cracking. Aggregate small enough to insure proper placement without bridging should be used. The finished product should be free from honeycombing or other defects likely to impair the ability of the concrete structure to remain watertight.

Precast concrete casing is usually composed of concrete rings, from 3 to 5 feet in diameter, and approximately 3 feet in length. To serve satisfactorily as casing, these rings should be free of any blemishes that would impair their strength or watertightness. They should conform to the specifications contained in the following publications:

1. American Water Works Association (AWWA C300).
"Standard for Reinforced Concrete Water Pipe-
Steel Cylinder Type, Not Prestressed."
2. American Water Works Association (AWWA C301).
"Standard for Reinforced Concrete Water Pipe-
Steel Cylinder Type, Prestressed."

Drive Shoe

All driven casing should be equipped with a standard weight drive shoe. The drive shoe should be attached to the bottom of the casing by a screw-type joint or by continuous welds both inside and outside the casing.

Placement

The installation of all casing should be accomplished in such a manner that any possible damage to casing section or to the joints is avoided. When precast concrete casing is used in any well, the casing should rest upon an adequately designed footing or platform at the bottom of the well to prevent settling which would cause cracking and failure of the casing. To reduce the possibility of honeycombing or separation of poured concrete, free fall of the concrete should not be allowed.





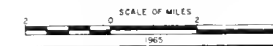
LOCATION MAP

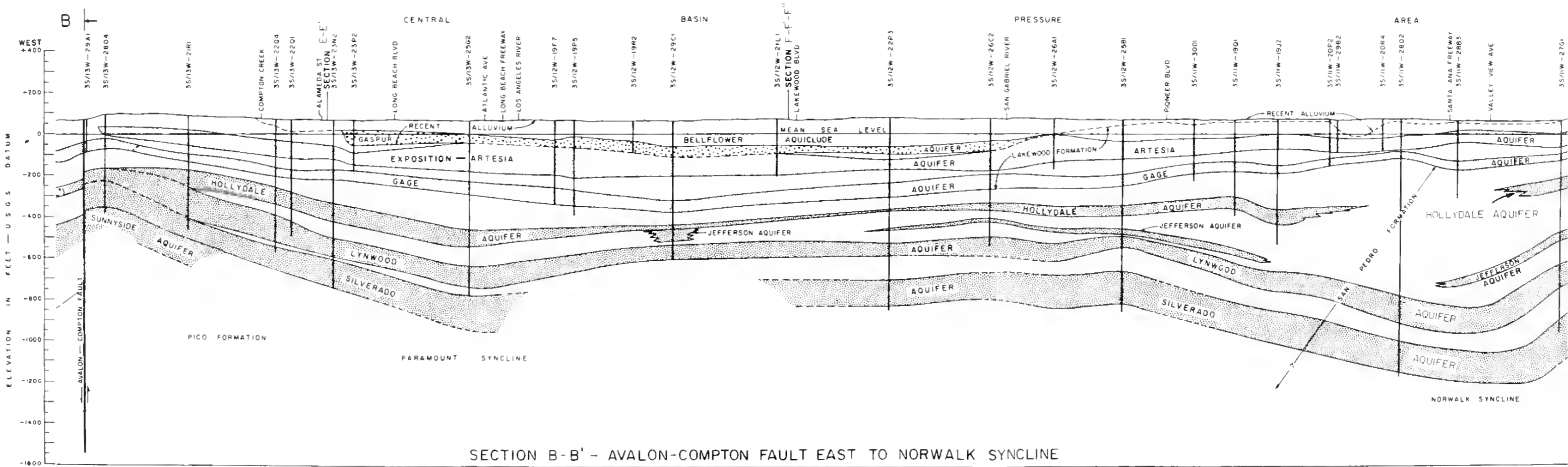
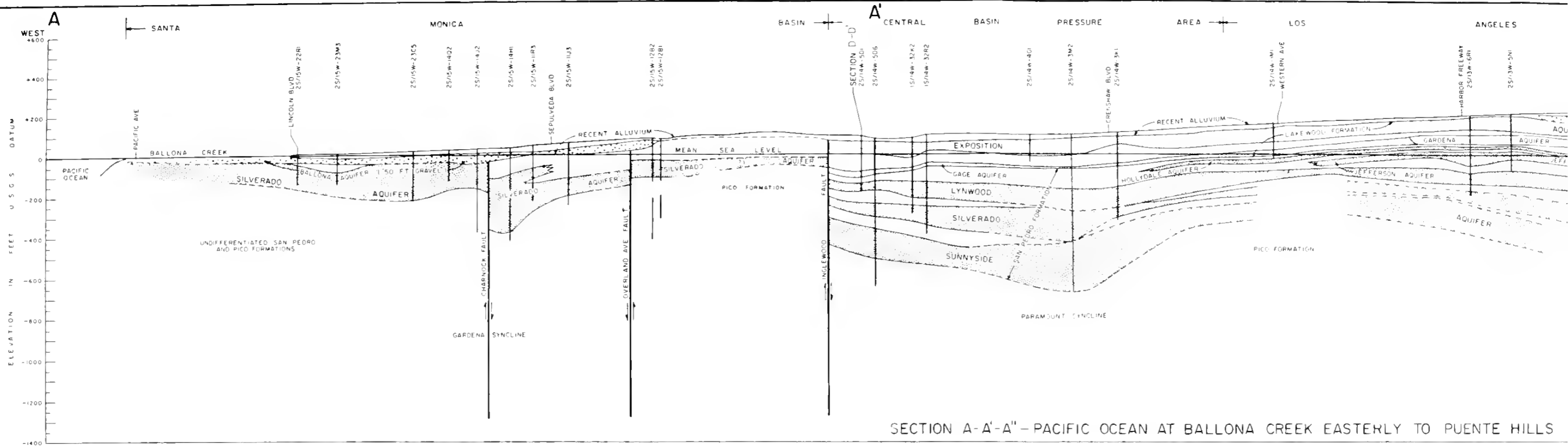
LEGEND

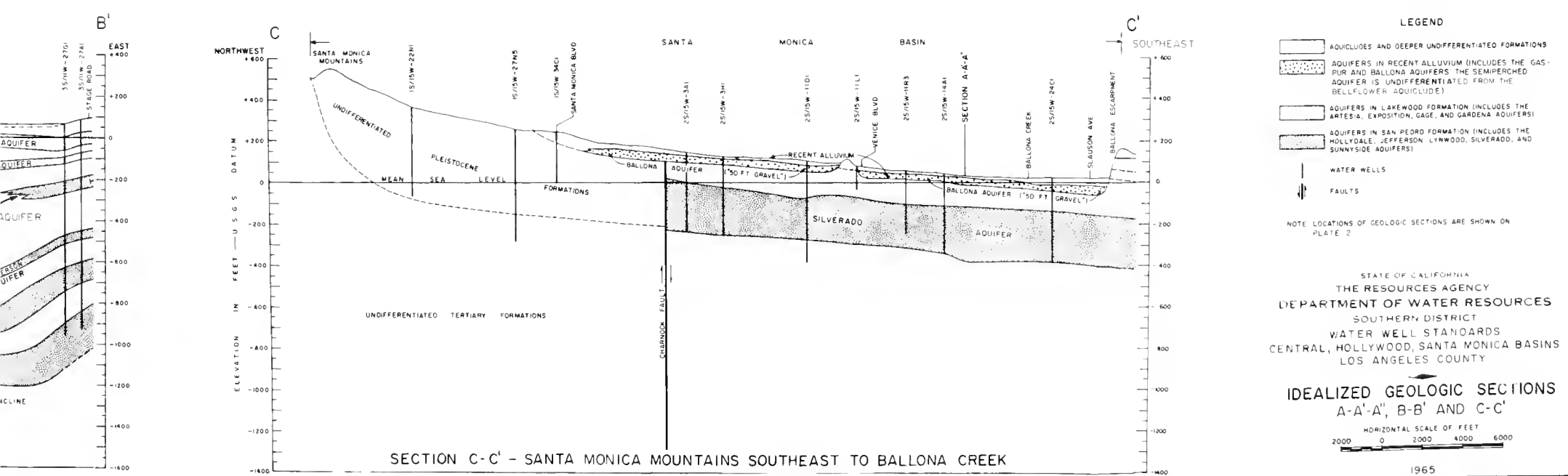
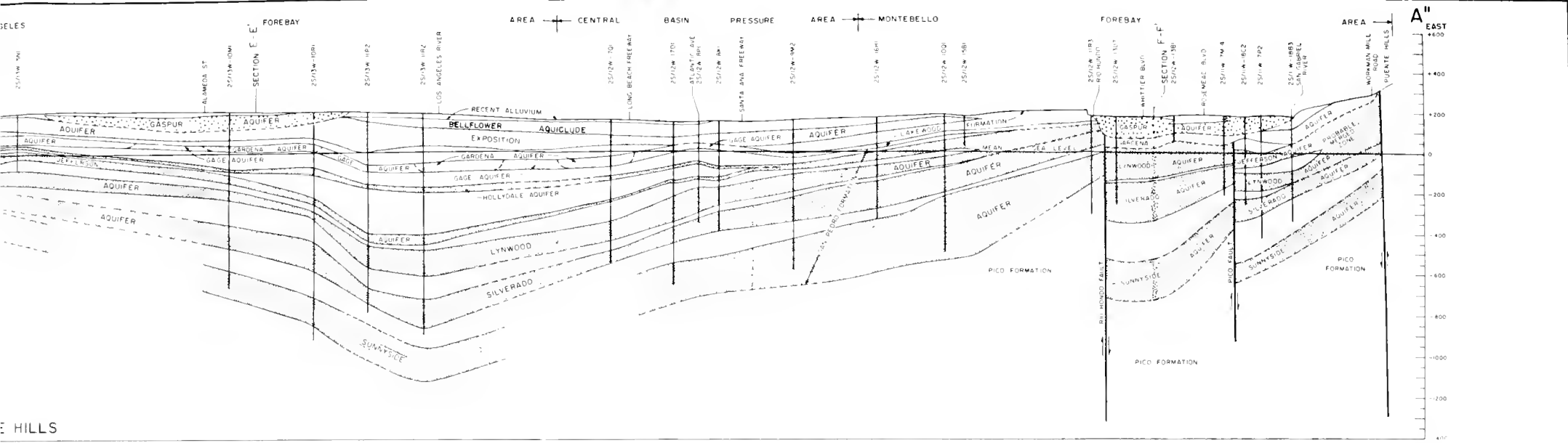
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- BOUNDARY OF WATER BEARING MATERIAL
- - - BOUNDARY OF FOREBAYS AND WHITTIER AREAS
- ▨ AREA OF INVESTIGATION

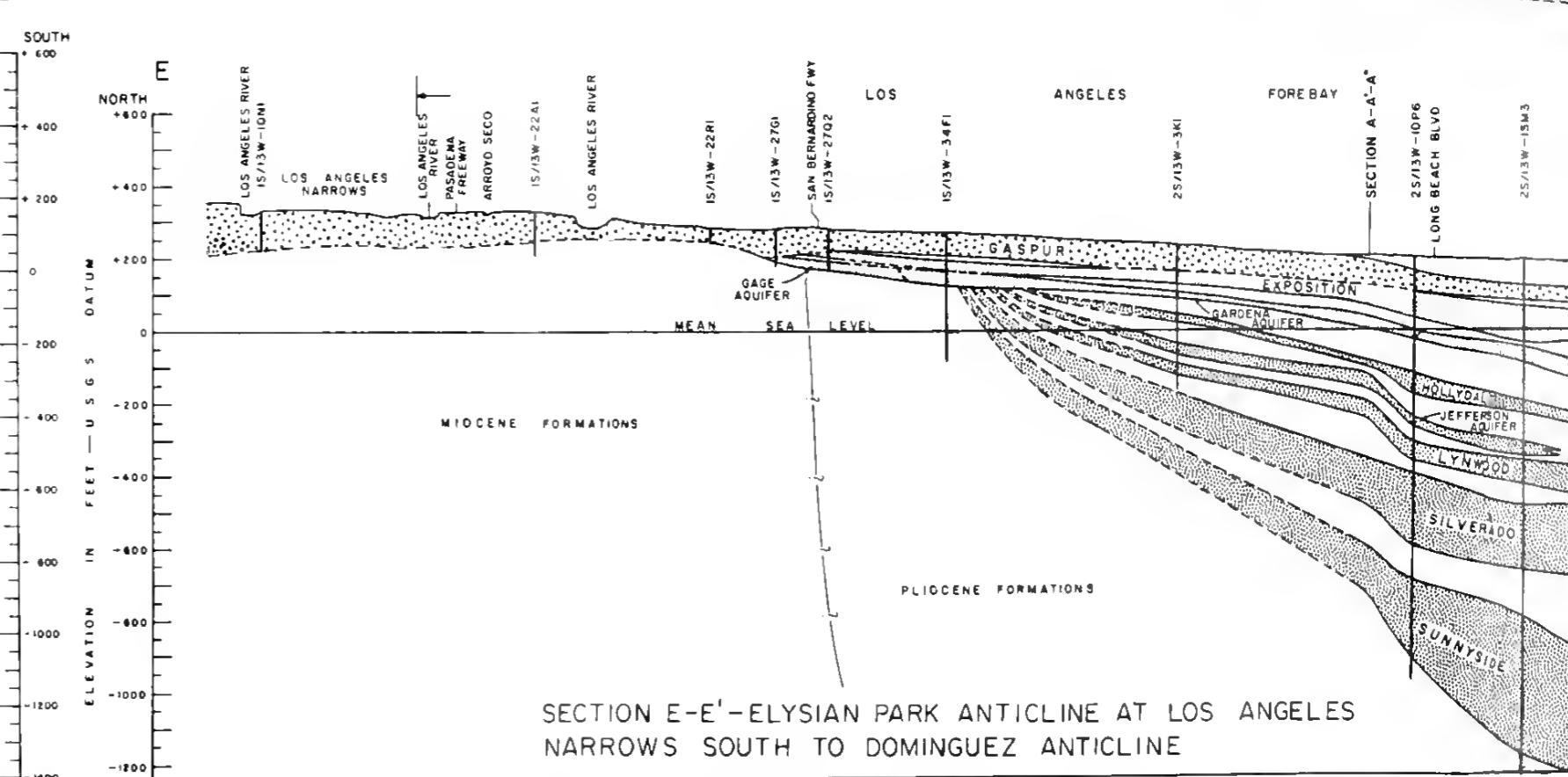
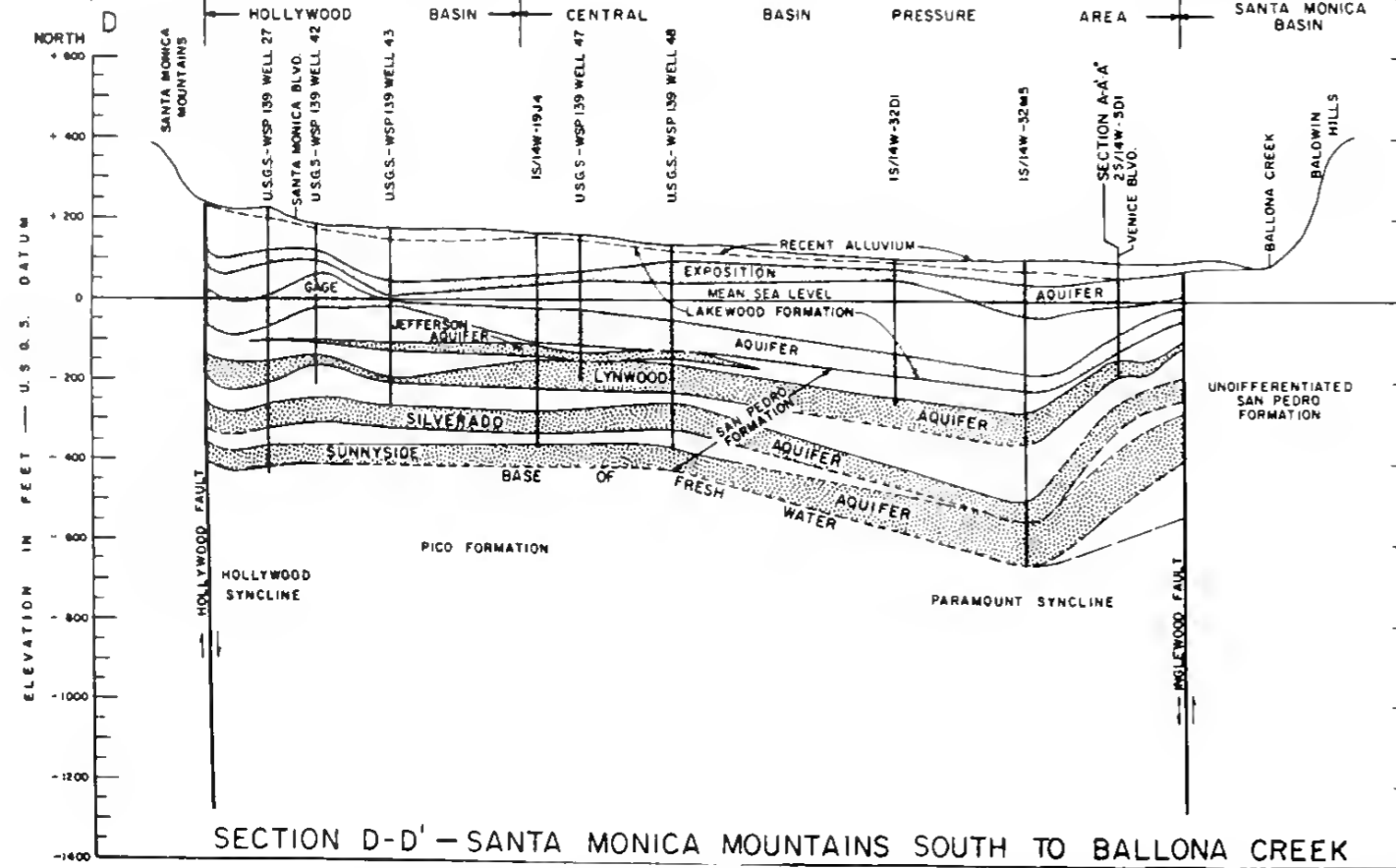
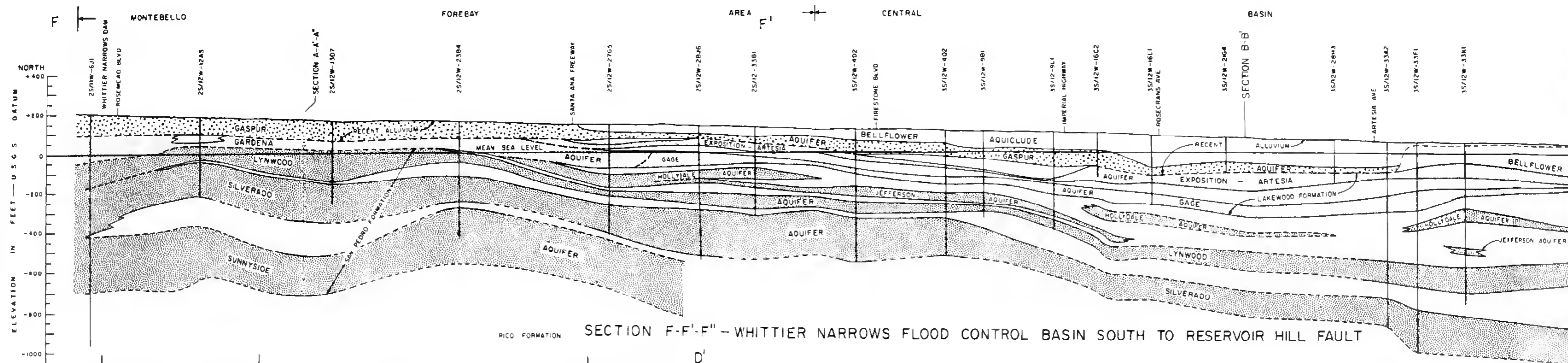
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
WATER WELL STANDARDS
CENTRAL, HOLLYWOOD, AND SANTA MONICA BASINS
LOS ANGELES COUNTY

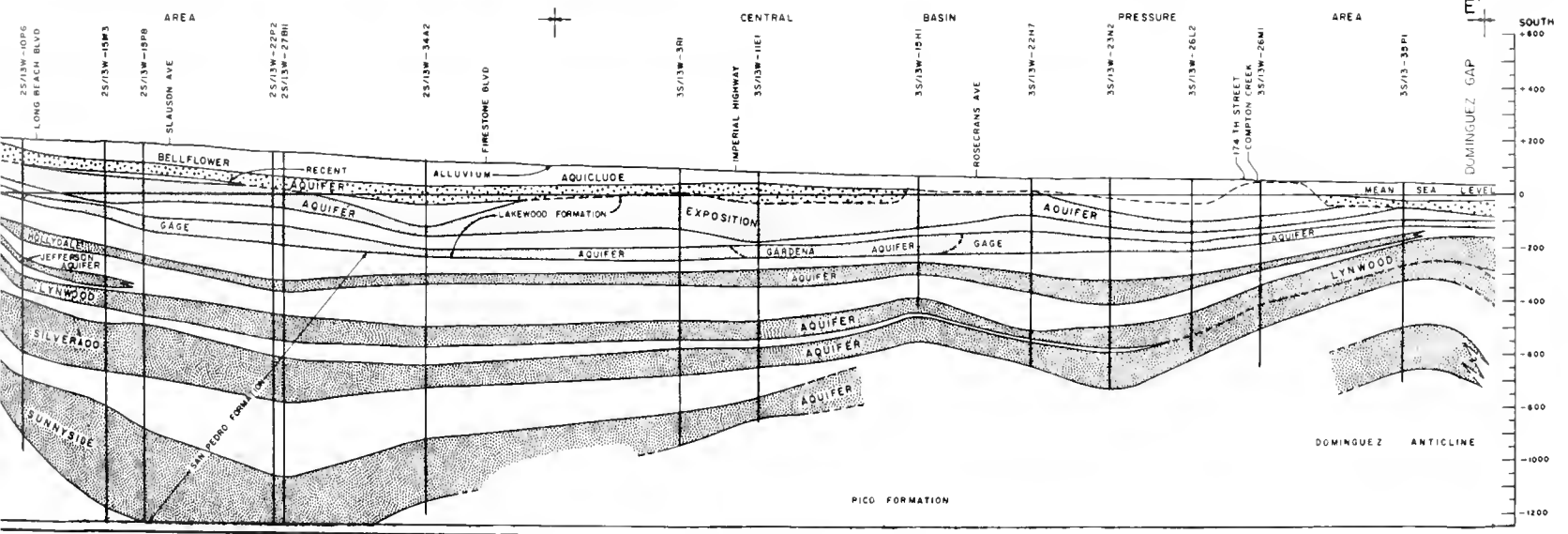
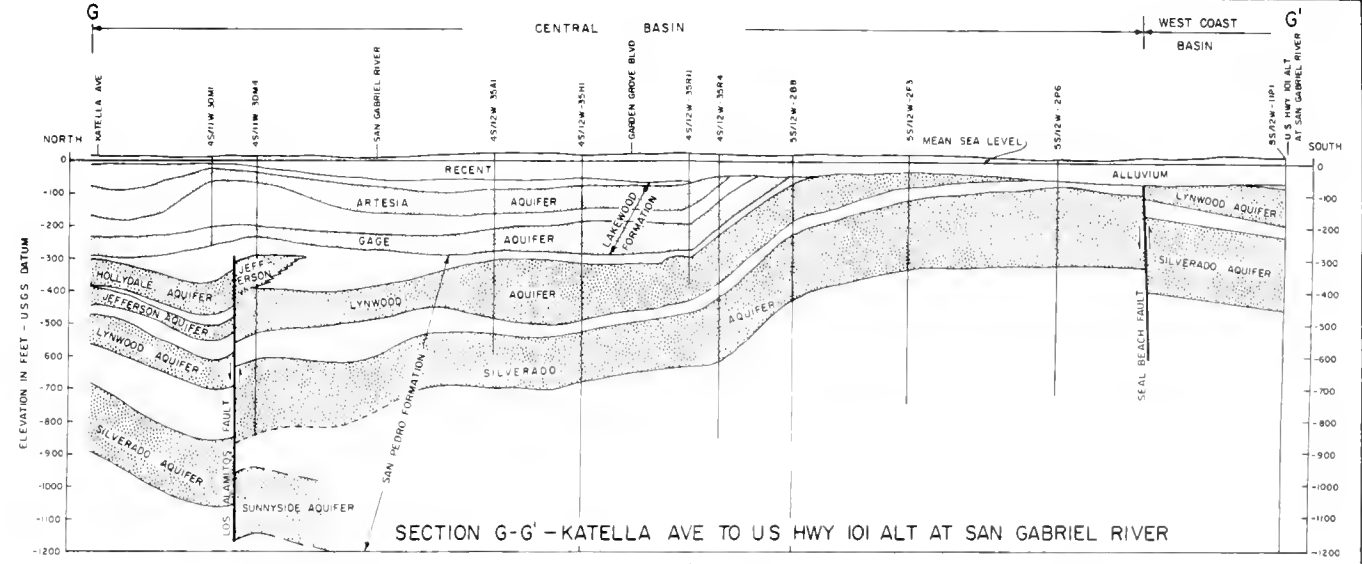
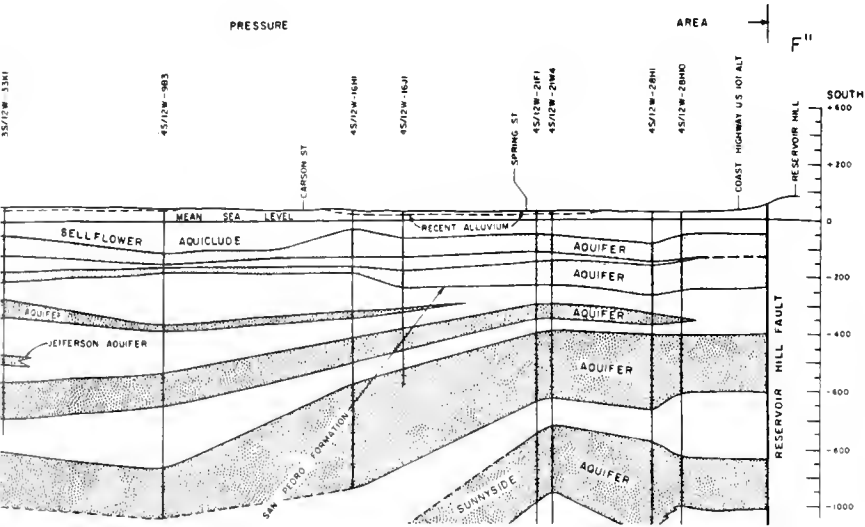
GROUND WATER BASINS IN
COASTAL PLAIN OF
LOS ANGELES COUNTY











LEGEND

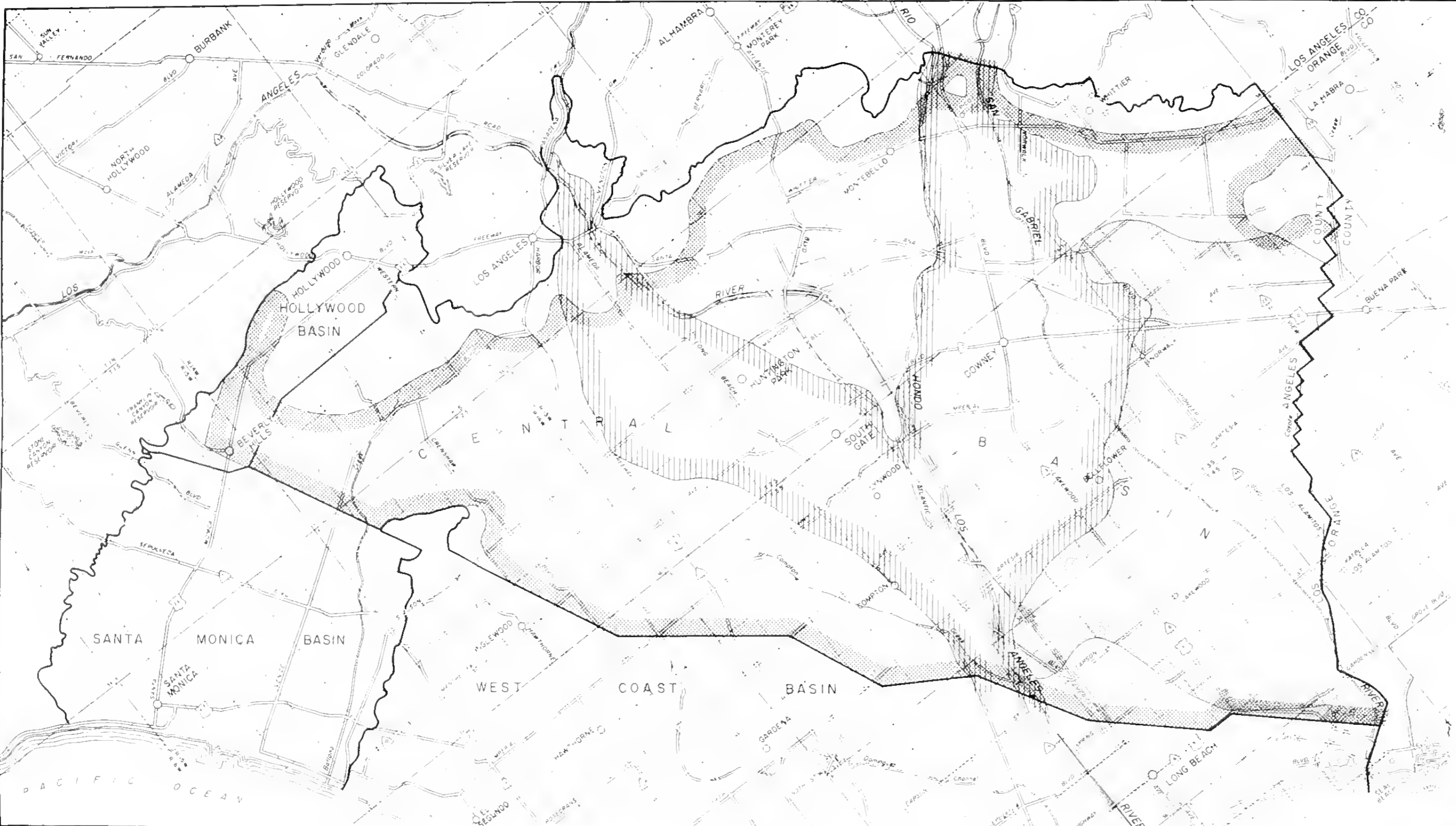
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- AQUIFERS IN RECENT ALLUVIUM (INCLUDES THE GAGE AND BALLONA AQUIFERS; THE SEMIPERCHED AQUIFER IS UNDIFFERENTIATED FROM THE BELLFLOWER AQUICLUDE)
- AQUIFERS IN LAKEWOOD FORMATION (INCLUDES THE ARTESIA, EXPOSITION, GAGE, AND GARDENA AQUIFERS)
- AQUIFERS IN SAN PIEDRO FORMATION (INCLUDES THE HOLLYDALE, JEFFERSON, LYNWOOD, SILVERADO, AND SUNNYSIDE AQUIFERS)
- WATER WELLS
- FAULTS

NOTE: LOCATIONS OF GEOLOGIC SECTIONS ARE SHOWN ON PLATE 2

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
WATER WELL STANDARDS
CENTRAL, HOLLYWOOD, SANTA MONICA BASINS
LOS ANGELES COUNTY

**IDEALIZED GEOLOGIC SECTIONS
F-F', G-G', D-D' AND E-E'**

HORIZONTAL SCALE OF FEET
2000 0 2000 4000 6000
1965



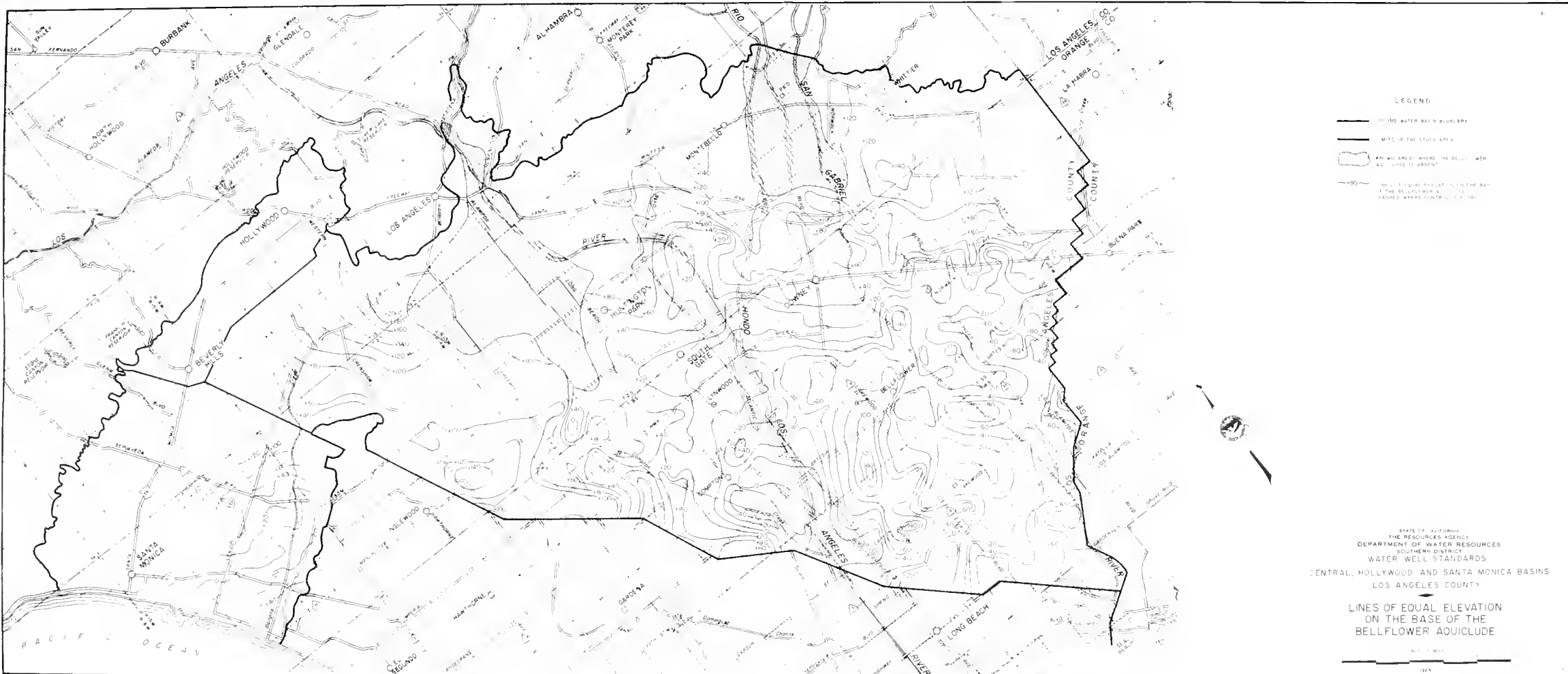
- LEGEND
- GROUND WATER BASIN BOUNDARY
 - AREAL EXTENT OF THE GASPOR AQUIFER
 - AREAL EXTENT OF THE ARTESIA AQUIFER
 - AREAL EXTENT OF THE LYNWOOD AQUIFER (BOUNDARY DASHED WHERE APPROXIMATE)

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT

WATER WELL STANDARDS
CENTRAL, HOLLYWOOD, AND SANTA MONICA BASINS
LOS ANGELES COUNTY

AREAL EXTENT OF AQUIFERS IN CENTRAL AND
HOLLYWOOD BASINS RELATED TO
SUPPLEMENTARY SEALING STANDARDS





LEGEND

— 100' WATER BASIN BOUNDARY

--- 100' WATER BASIN BOUNDARY

--- 100' WATER BASIN BOUNDARY

--- 100' WATER BASIN BOUNDARY

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SOUTHERN DISTRICT
WATER WELL STANDARDS
CENTRAL, HOLLYWOOD AND SANTA MONICA BASINS
LOS ANGELES COUNTY

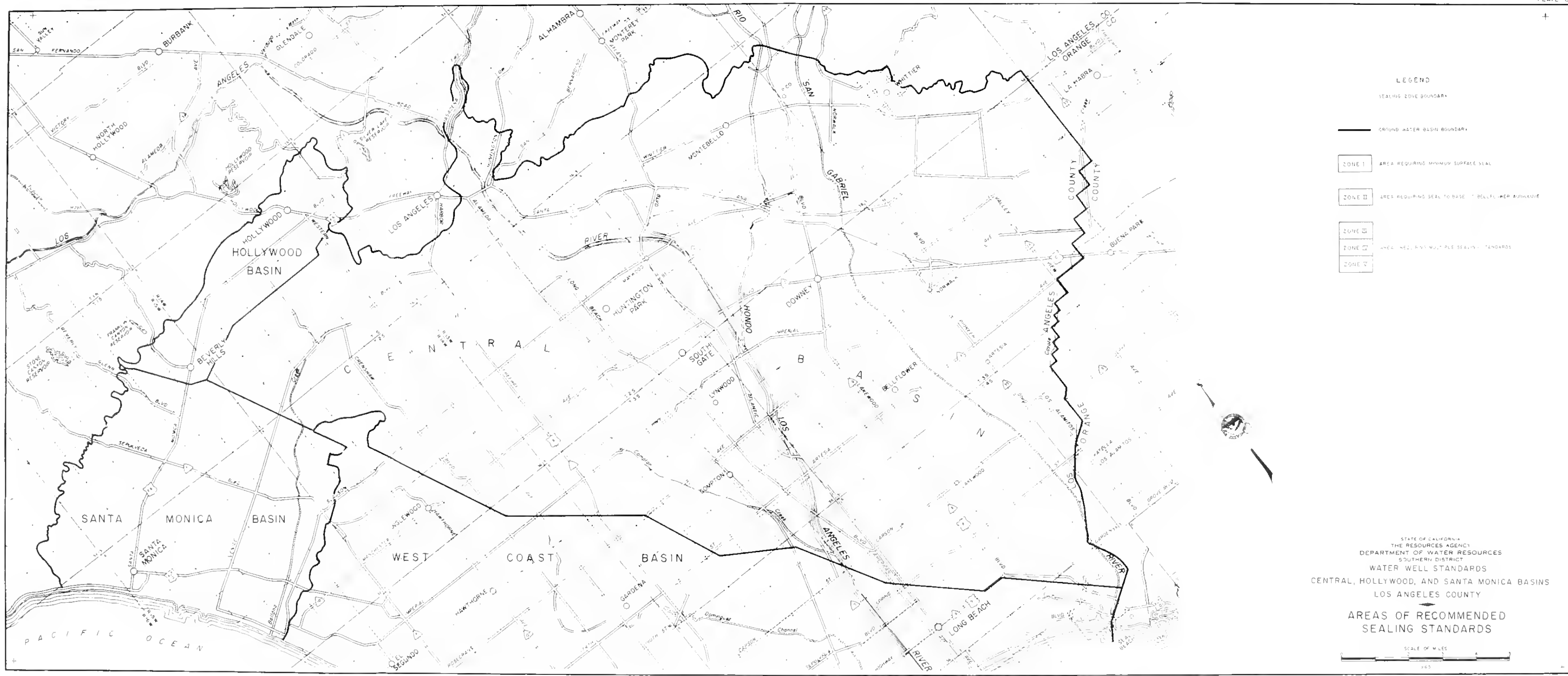
— 100' WATER BASIN BOUNDARY

--- 100' WATER BASIN BOUNDARY

--- 100' WATER BASIN BOUNDARY

--- 100' WATER BASIN BOUNDARY

1:50,000



LEGEND

SEALING ZONE BOUNDARY

GROUND WATER BASIN BOUNDARY

ZONE I AREA REQUIRING MINIMUM SURFACE SEAL

ZONE II AREA REQUIRING SEAL TO BASE "BELLFLOWER AUTHORITY"

ZONE III

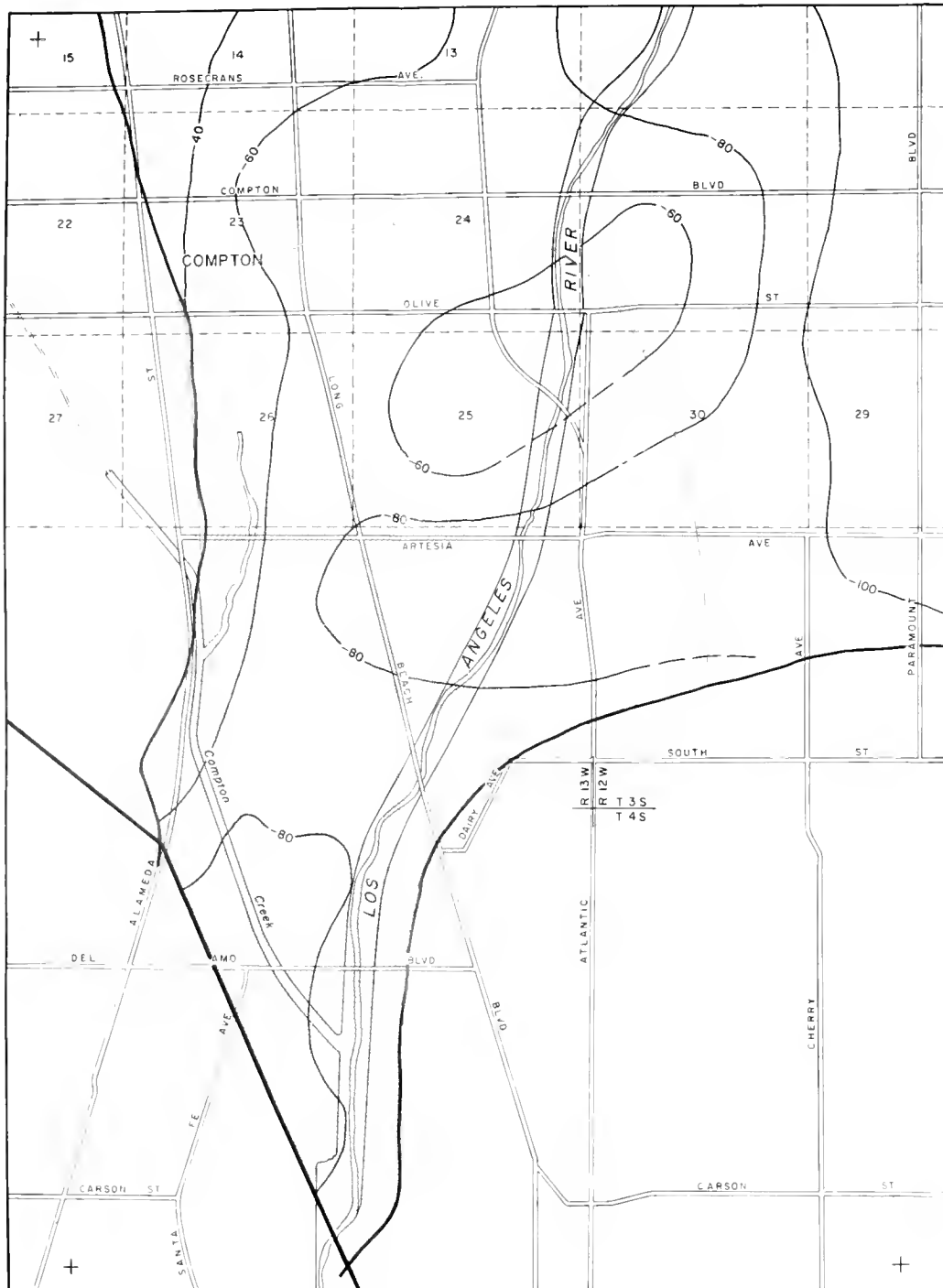
ZONE IV AREA REQUIRING MULTIPLE SEALING STANDARDS

ZONE V

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SOUTHERN DISTRICT
WATER WELL STANDARDS
CENTRAL, HOLLYWOOD, AND SANTA MONICA BASINS
LOS ANGELES COUNTY

AREAS OF RECOMMENDED
SEALING STANDARDS

SCALE OF MILES
0 1 2 3 4 5



LEGEND

—80— LINE OF EQUAL ELEVATION ON BASE OF GASPUR AQUIFER

— BOUNDARY OF GASPUR AQUIFER

— BASIN BOUNDARY

EXTENT OF POOR QUALITY WATER IN GASPUR AQUIFER CONTAINING MORE THAN 700 PARTS PER MILLION TOTAL DISSOLVED SOLIDS

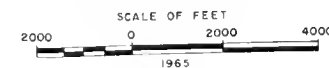
BOUNDARY OF SEALING ZONE III

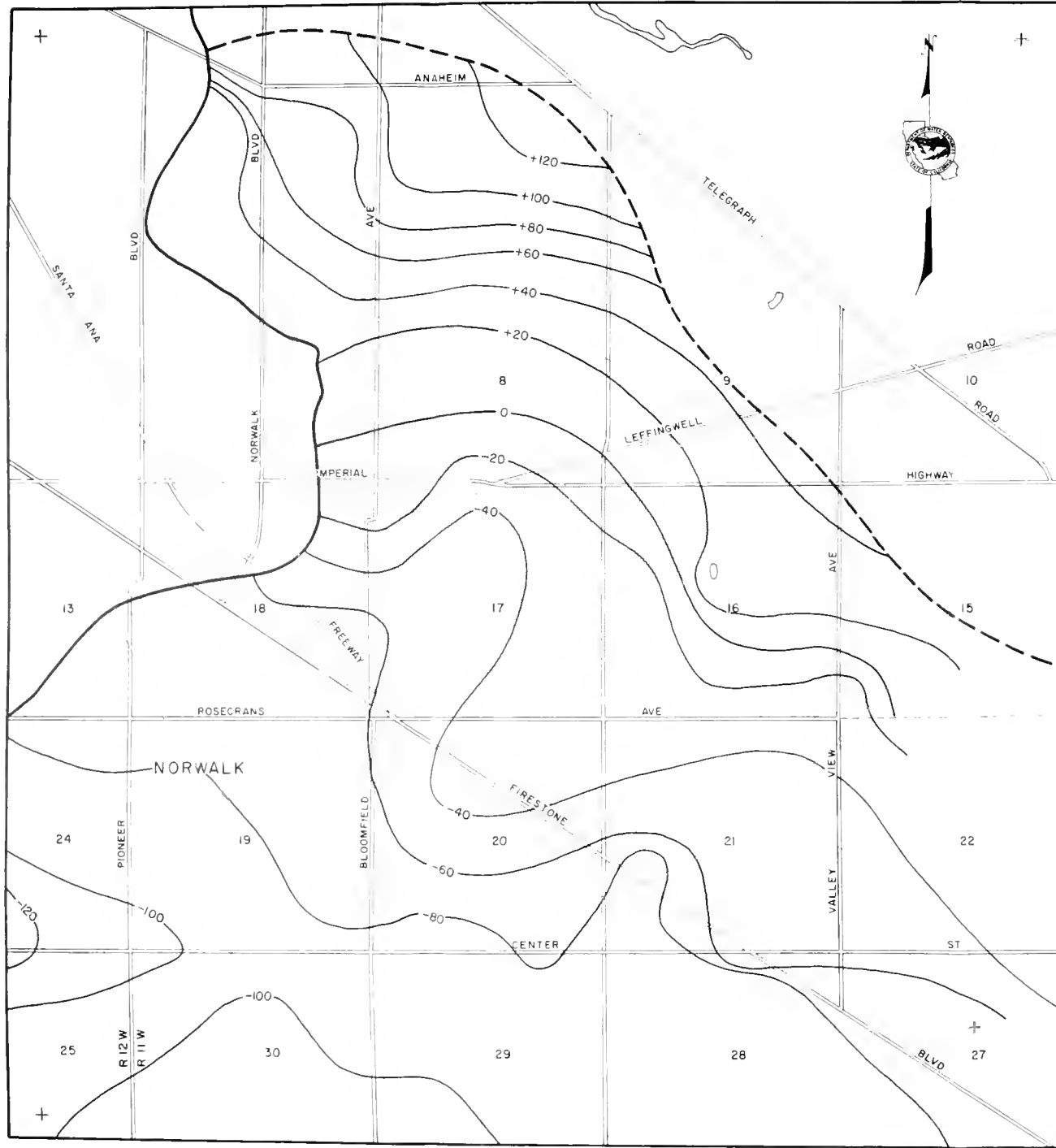
NOTE CONTOURS ARE REFERENCED TO MEAN SEA LEVEL U.S. GEOLOGICAL SURVEY DATUM

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WATER WELL STANDARDS
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SANTA MONICA BASINS
LOS ANGELES COUNTY

WATER WELL SEALING ZONE III
DOMINGUEZ GAP





T
3
S.

LEGEND

— -40 — LINE OF EQUAL ELEVATION ON BASE OF ARTESIA ZONE

———— EAST BOUNDARY OF GASPAR AQUIFER

AREA OF SUSPECTED POLLUTION

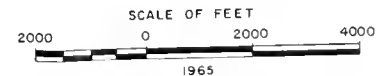
- - - - - NORTHEAST BOUNDARY OF ARTESIA AQUIFER

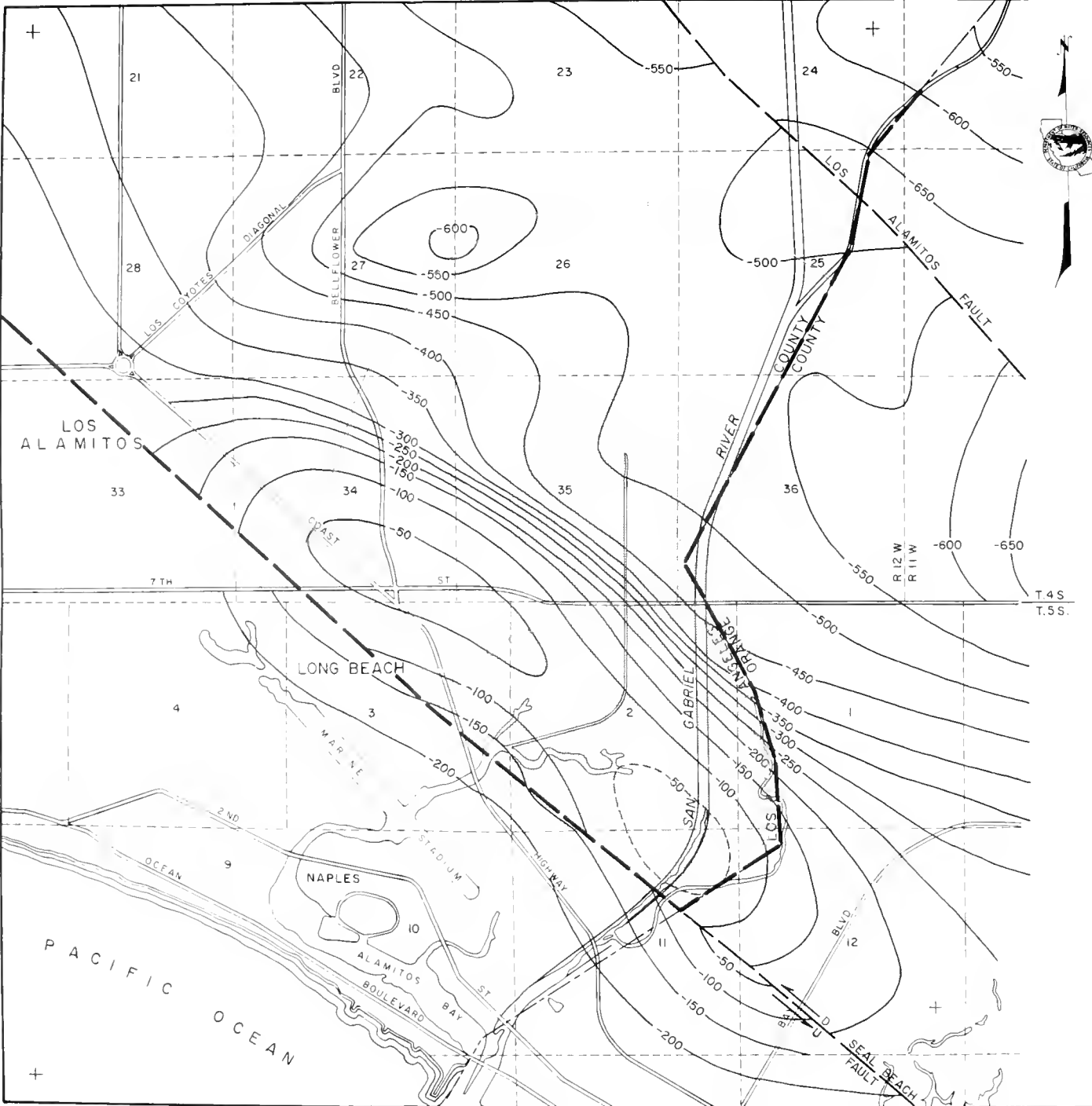
BOUNDARY OF SEALING ZONE IV

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WATER WELL SEALING ZONE IV
NORWALK AREA





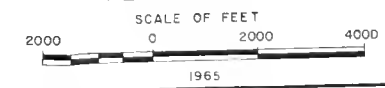
LEGEND

- 150- LINE OF EQUAL ELEVATION ON THE BASE OF THE LYWOOD AQUIFER
- U ←
0 →
D Fault (Dashed where approximately located, arrows indicate direction of relative lateral movement, U - UPRHTHROWN SIDE; D - DOWNTHROWN SIDE)
- NORTH BOUNDARY OF SEALING ZONE V
- EXTENT OF SEA WATER INTRUSION SPRING 1963 (WATERS CONTAINING IN EXCESS OF 500 PARTS PER MILLION CHLORIDE)
- BASIN BOUNDARY
- PROPOSED LINE OF INJECTION WELLS FOR THE ALAMITOS BARRIER PROJECT (LOS ANGELES COUNTY FLOOD CONTROL DISTRICT AND ORANGE COUNTY WATER DISTRICT)

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